AI Magazine Volume 19 Number 2 (1998) (© AAAI)

The Eleventh International Workshop on Qualitative Reasoning

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■ The Eleventh International Workshop on Qualitative Reasoning was held in Cortona, Italy, on 3 to 6 June 1997. Participants included scientists from both qualitative reasoning and quantitative mathematical modeling communities. This article summarizes the significant issues and discussion raised during the workshop.

The Eleventh International Workshop on Qualitative Reasoning (QR '97) was held on 3 to 6 June 1997 at Il Palazzone, an imposing and regal sixteenth-century villa in the medieval town of Cortona, Tuscany, Italy. Sixty-four people participated, and 39 papers were presented in either oral or poster sessions. The meeting was sponsored by Istituto di Analisi Numerica (IAN) - C.N.R., the American Association for Artificial Intelligence, IllyCaffè, the Italian Association for Artificial Intelligence, OCC'M Software GmbH, Stigma s.r.l - Pavia, and Xerox Palo Alto Research Center. The support that was also given by academic and industrial institutions that are not traditionally devoted to AI research but, rather, to modeling methodologies and their applications highlights the intrinsic interdisciplinary nature of qualitative reasoning research. However, the evolution of qualitative reasoning research to increasingly sophisticated methods and techniques, along with their application to increasingly complex domains, inevitably requires a strong interaction with those communities that have traditionally been devoted to mathematical modeling. QR '97 broke with tradition in that it was organized by an institution, the Istituto di Analisi Numerica - CNR of Pavia, whose main focus is quantitative mathematical modeling in the domain of applied sciences, although a research project on qualitative reasoning methods and their integration with quantitative reasoning methods has been active since 1988. Given the organizational context, an additional goal in our minds in preparing the workshop was to establish a basis for interaction between the qualitative and quantitative communities.

To this end, in addition to the presentation of full papers, posters, and short talks, in line with past workshop schedules, we planned invited talks, the focuses of which were problem domains for qualitative reasoning in real-world applications, and a tutorial on system identification. In particular, Furio Suggi-Liverani (IllyCaffè - Trieste) discussed the problems related to the formulation of a quantitative model of the espresso coffee brewing dynamics; G. Zanetti and G. Fotia (CRS4 - Cagliari) focused on problems of interpreting massive data streams coming from latest-generation medical-imaging equipment and of modeling of liquid-solid interaction, respectively. A tutorial entitled "System Identification: Problems and Perspectives" was presented by G. De Nicolao (University of Pavia). The tutorial gave an overview of the main problems (identifiability, overparameterization, model comparison) arising in system identification from data. The tutorial was appreciated by the participants because this topic is of fundamental importance in automated modeling.

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A valuable impact of qualitative reasoning to system identification is confirmed by three papers presented at the workshop. E. Bradley, A. O' Gallagher, and J. Rogers (all of the University of Colorado) presented a tool that uses qualitative information to improve parameter-estimation techniques. This work is part of a more general tool for automated system identification and aims at finding optimal parameter choices to match a nonlinear ordinary differential equation model to data without getting trapped in local minima. S. Reece (University of Oxford) addressed the problem of data fusion and parameter estimation for noisy processes when the process models are incomplete or imprecise. The noisy data are filtered by a qualitative Kalman filter proposed by the author. The paper by A. Steele and R. Leitch (both of University of Edinburgh) addressed the problem of qualitative parameter identification and presented an exhaustive search technique to estimate parameters in a fuzzy qualitative model.

Another important issue discussed from both the quantitative and qualitative sides was the classification and interpretation of massive data sets. In addition to the talk given by one of the invited speakers, two presentations focused on this subject. Both presentations were based on a framework for spatial aggregation (past work by C. Bailey-Kellog, F. Zhao, and K. Yip). C. Bailey-Kellog and F. Zhao (both of Ohio State University) presented a possible application of spatial aggregation for the description and interpretation of distributed parameter physical fields, whereas Yip (Massachusetts Institute of Technology) highlighted the descriptive potential of spatial aggregation in interpreting fluid-flow simulation data by extracting three-dimensional structures, classifying them, and analyzing their spatial and temporal coherence.

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A remarkable example of how far the integration of qualitative and quantitative methods can lead was presented by L. Joskowicz (The Hebrew University, Jerusalem) and E. Sacks (Purdue University). The work dealt with a unified approach to computer-aided mechanical assembly design: Such a task is primarily accomplished by contact analysis, which is automated by configuration-space computation.

Qualitative simulation continues to be a key research topic and contribution of the qualitative reasoning community. The major difficulty in qualitative simulation is intractable branching as a result of chatter variables. D. Clancy and B. Kuipers (both of University of Texas at Austin) presented a novel solution, which potentially allows the QSIM algorithm to tackle much larger problems, for the elimination of chatter using a dynamic analysis of the model and the current state. An important analysis of the application of QSIM to real problems (nonlinear control systems) was given by M. Hofbaur (University of Graz). He illustrated problems with the current stability test and provided new methods that perform a more accurate stability test for uncertain systems. The expressive power of the QSIM representation, as well as the limitation in the real applicability of the higher-order derivative method in QSIM, was discussed by A. C. C. Say (Bogazici University). A new task, based on qualitative simulation, was proposed by the preliminary but promising work for plan generation for system controls by G. Brajnik (University of Udine) and Clancy.

Qualitative reasoning has been considered essential for tasks such as diagnosis, involving complex dynamic systems for which precise models either do not exist or are too complex to compute with. P. Struss, M. Sachenbacher, and F. Dummert (all of Technical University of Munich and Robert Bosch GmbH) presented a case study in model-based (off-board) diagnosis of the hydraulic circuit of an antilock braking system, where both the model and measurements of the actual behavior are very incomplete. The presented results demonstrated that by using models of the qualitative deviations of variables and parameters from the nominal values, qualitative state-based diagnosis can suffice to diagnose complex dynamic systems. Further work on the automotive domain was presented by N. Snooke and C. Price (both of University of Aberystwyth), who tried to identify current problems and challenges for qualitative electrical reasoning in this domain.

Continuing the trend from previous years, modeling was one of the key issues. The work by H. Ahriz (University of Savoie) and S. Xia (De Monfort University) dealt with a framework for automated modeling and fault diagnosis. Such a framework is grounded on the bond-graph modeling methodology. Bond-graph representation was also used by P. Mosterman and G. Biswas (both of Vanderbilt University) to establish a formal specification for handling hybrid systems, that is, mixed discrete-continuous systems. The process of model revision by exploiting qualitative simulation results was addressed by Clancy, Brajnik, and B. Kay (University of Texas at Austin), who provided a tool to help the modeler search the space of potential models, thus simplifying the model-revision process. P. Salles (University of Edinburgh) and B. Bredeweg (University of Amsterdam) presented a library of model fragments for reasoning about the behavior of ecological communities as well as guidelines for the construction of reusable models.

Several researchers proposed new qualitative reasoning paradigms: I. Bratko (University of Ljubljana) discussed qualitative representations for human skill acquisition and reconstruction. A. Farley (University of Oregon) introduced a qualitative theory of argumentation for issues of ambiguity resolution in qualitative reasoning about complex systems. V. Haarslev and R. Möller (both of University of Hamburg) addressed the issue of unifying qualitative and quantitative spatial reasoning and terminological reasoning. L. Travé-Massuyès and R. Pons (both of LAAS-CNRS) proposed an extension to the original causal-ordering theory to multimodal devices.

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Valpiani (University of Torino). The system is based on a cognitive theory of commonsense reasoning about everyday physical situations and uses an extended version of QPT. The paper by K. de Koning, B. Bredeweg, and J. Breuker (all of University of Amsterdam) addressed the problem of making qualitative simulation results more useful for teaching by abstracting away irrelevant and uninteresting details to produce a more aggregated structure of inference steps that better reflects the way people think.

The variety of applications of qualitative reasoning technologies to the different domains presented, ranging from economy to ecology, engineering, and neurosciences, was both a great opportunity to discuss new and old research issues and an exciting source of new research problems. The workshop notes contain all the papers and abstracts presented and are made available from IAN-CNR as part of its technical report series (no. 1036).

In line with the tradition of switching between North America and the rest of the world, the 1998 Qualitative Reasoning Workshop will be held in Cape Cod, Massachusetts, and cochaired by Feng Zhao and Ken Yip, whereas QR '99 will be held in the United Kingdom and organized by Chris Price. The next qualitative reasoning workshops will schedule a joint session with principles of diagnosis workshops to promote an active discussion on the topics of common interest. This arrangement will further contribute to more and more stimulating and lively interactions between the participants, with a consequent greater success of the future workshops.

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