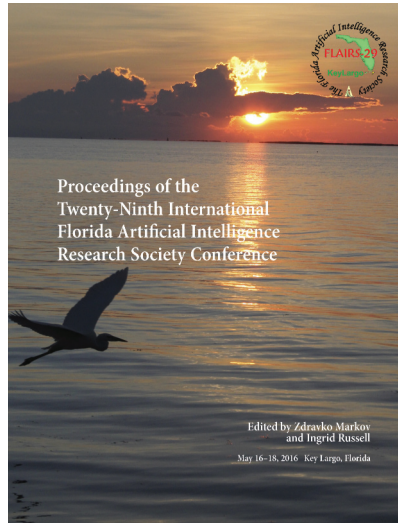


Qualitative Reasoning: Everyday, Pervasive, and Moving Forward — A Report on QR-15

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■ *The 28th International Workshop on Qualitative Reasoning (QR-15) presented advances toward reasoning tractably with massive qualitative and quantitative models, automatically learning and reasoning about continuous processes, and representing knowledge about space, causation, and uncertainty.*

The 28th International Workshop on Qualitative Reasoning (QR-15) was held in Minneapolis, MN on August 10–11, 2015. The technical track included two invited talks, 11 oral presentations, and 5 poster presentations. All of the research presented at QR-15 utilized qualitative representations of space, physical systems, causality, or uncertainty, but the domains of application were diverse: we saw a qualitative model of uncertainty demonstrated in a cybersecurity domain, which was robust to sensor noise and incomplete knowledge (Robert Goldman, SIFT); we learned about extensions to frame semantics for modeling continuous processes (Clifton McFate, Northwestern); we discussed multiple strategies for encoding topological relations and generating proofs over qualitative spatial descriptions; we learned about novel applications of process-oriented modeling to ecology and limnology (Peter Struss, TUM); we heard news of terabyte-scale qualitative simulations to automatically vet designs of cyber-physical systems (Johan de Kleer, PARC); and we discussed qualitative graph abstraction tech-



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niques (Scott Friedman, SIFT) that may ultimately reduce the size of these qualitative simulations and thereby improve efficiency.

Kenneth Forbus (Northwestern) delivered an invited talk on qualitative reasoning in the everyday world. Forbus's talk focused on the pervasiveness of qualitative knowledge and qualitative reasoning in everyday cognition. Elementary-level science exams — some of which are used to assess the reasoning capabilities of AI systems — are composed of problems that demand qualitative reasoning and knowledge of continuous processes and qualitative proportionality. This is evidence that qualitative reasoning is a central component of everyday human cognition and formal education, and it suggests that qualitative reasoning should be a key focus for building human-level artificial intelligence. This pervasiveness of qualitative reasoning motivates the community's work on automatically building or acquiring qualitative models of the world, such as by experiential learning or reading science texts. Clifton McFate (Northwestern) presented work on frame semantics of continuous processes, which supports these goals of learning qualitative models from texts.

Johan de Kleer (PARC) delivered an invited talk on lessons learned from the Adaptive Vehicle Make program. The talk focused on the challenges of model-based reasoning and qualitative simulation at massive scale. One such challenge is prioritizing the expansion of the state space in a purely structural qualitative or quantitative model. This triggered a long discussion of our workshop audience on the

topic of adding sound functional knowledge to our structural qualitative models. When human experts build qualitative or quantitative models of complex systems, they use the function of the system as a guideline to decide what to model and how to model it, yet they do not often encode this functional knowledge directly. If qualitative and quantitative models contained this functional knowledge, our reasoning systems might use it as a heuristic or as a filter during the course of quantitative and qualitative simulation. Matthew Klenk (PARC) delivered a separate talk related to massive-scale model-based reasoning, describing the challenge of choosing initial conditions for simulation.

Throughout the technical presentations on advances in qualitative simulation, we discussed the practicality of automatically transforming quantitative and qualitative models during the course of reasoning. Much like human modelers, qualitative reasoning systems would have the flexibility to revise autonomously the preconditions, consequences, participants, and granularity of its models and evaluate the resulting model for corroboration with observations. This would improve the flexibility of qualitative and quantitative simulation, and it would also potentially compensate for the incompleteness or incorrectness of human-made models.

A final theme that attendees discussed with interest was qualitative spatial representations. Andrew Lovett (Northwestern) presented psychological evidence that people encode qualitative topological relations in their working memory, due to people's increased ability to remember changes in a scene when they differ in qualitative topology. Sahib Jan (University of Muenster) presented extensions to region connection calculus to describe line or point contact of adjacent regions, which improves automated comparison and inference in sketch maps. Also in the sketching domain, Matthew McLure (Northwestern) presented work on detecting and summarizing textures to improve learning and categorization of sketches, and Maria Chang (Northwestern) described progress on using sketches within multimodal instructional analogies as the basis for intelligent educational software.

We decided that the International Workshop on Qualitative Reasoning should continue to be an annual event, collocated with other academic artificial intelligence conferences such as IJCAI and AAI. Details of QR-16 will be publicized as soon as they are finalized.

Scott Friedman and Kate Lockwood chaired the QR-15 workshop.

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