

Temporal Representation and Reasoning

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Artificial intelligence research in temporal reasoning focuses on designing automated solutions to complex problems in computation involving time. TIME-97, the 4th International Workshop on Temporal Representation and Reasoning, held in Daytona Beach, Florida—like the three workshops that preceded it—had the objective of creating an international forum for the exchange of information among the many researchers and knowledge engineers who are developing and applying techniques in temporal reasoning.

The previous TIME workshops successfully provided a mechanism for people involved in temporal reasoning in AI to form a sense of community. One result of the workshops has been an increase in communication among these professionals. TIME-97 continued to widen and strengthen ties among the temporal reasoning community by providing a forum for talks on successful applications and ongoing research and development in temporal reasoning. The TIME workshops are indeed international, having participants from Europe, especially Great Britain and Italy, the United States and Canada, South America, and Korea.

TIME-97 was highlighted by two exceptional invited talks, one each by Patrick Hayes and Mark Boddy, as well as by a wide range of high quality technical papers, both theoretical and applied. The invited talk by Pat Hayes, currently professor of computer science at the University of West Florida, opened the workshop. Hayes' talk was divided into two, somewhat independent sections. The first section focused on the nature of the time-line. It is generally assumed that if time is continuous, then the real line is the appropriate model of the local structure of the time-line. In this conception, intervals are viewed as sets of points. An alternative vision is based more closely on Allen's 13 temporal relations, and does not seem compatible with the real line conception, especially when the focus is on "very small" intervals. Hayes' account allowed the audience to more clearly see where the differences in the two accounts arise, and offered a simple, but intuitive, solution to some of these problems in terms of the notion of "negative intervals", i.e. intervals with negative duration. Very small intervals could be viewed as those which were identical to their negative counterparts.

The second part of Hayes' talk discussed the problem of "now". This indexical is not like others, such as "here" and "I", and any attempt at coming to grips with its meaning raise interesting quandaries. An indexical like "here", for example, refers to a changing location, a location that changes as the user of the indexical changes the reference point. By contrast, "now" refers to an instant of time that changes "over time". Hayes was convincing in his claim that this dual reference to time in interpreting what "now" means is perplexing.

Mark Boddy, researcher at the Honeywell Technology Center, gave the second invited talk as the opening event on the second day of the workshop. Boddy's talk was titled "Practical Temporal Reasoning for Real Scheduling Applications". Honeywell is involved with a number of development projects in manufacturing, logistics, transportation, and spacecraft operations. Many of these projects require solutions to complex scheduling problems. Choosing the right temporal representation and inference methods is important, and there are often mutually incompatible requirements to satisfy, such as robustness and flexibility of the schedules generated. Boddy presented a set of requirements for modeling and solving scheduling problems, based on his experience in a wide variety of domains. Issues such as schedule repair, dynamic rescheduling, the importance of

negotiation and communication in correcting infeasible schedules, and the difficulty in achieving optimization, were discussed. Boddy also discussed the method of Constraint Envelope Scheduling, wherein schedules are incrementally built and evaluated for constraint violation and optimization.

The rest of the workshop consisted of technical paper presentations and posters. These papers tended to fit into one or more of the following categories:

- Temporal Logics.
- Representational Issues.
- Temporal Constraint Reasoning.
- Temporal Databases.

One group of presenters from Manchester Metropolitan University focused on improvements or extensions to temporal resolution reasoning in Propositional Temporal Logic (PTL) or Computation Tree Logic (CTL). Other papers focused on temporal abduction (Brusoni *et al.*), probabilistic temporal reasoning (Tawfik and Neufeld), temporal reasoning with preconditions (Cervesato *et al.*), and time in multiple theories (Mancarella *et al.*). Other new approaches to the representation of certain aspects of time offered potential solutions to complex problems of the sort raised by the invited talks. For example, the paper by Vidal and Fargier forged a distinction between contingent and free constraints within a temporal constraint network, a distinction useful in controlling the durations generated by a constraint solver. The papers by Terenziani in representing recurring events, and Shahar in temporal abstraction and interpolation, were also well presented and received. The latter paper, as well as the one by Blanco and Khatib on scheduling Space Shuttle maintenance tasks, were more applied in nature, and helped to re-confirm Boddy's points about the usefulness of temporal reasoning in solving real tasks.

The final large group of papers centered on temporal databases. The topics covered in these papers ranged from a presentation of a visual query language for temporal relational databases (Fernandes *et al.*), data clustering (Kim and Kim), concurrency control (Finger and McBrien), and object-oriented temporal databases based on a three-valued logic (Combi and Cucchi).

The poster session was well attended, and offered the participants the chance to cluster into small groups to discuss issues of interest related to the poster papers. The quality of the poster papers was high, and the program organizers found it difficult to distinguish the quality of the papers in the poster sessions from those in the technical sessions. Consequently, next year poster participants will be given a chance to present a short summary of their paper to the full workshop.

There was one social event associated with the workshop: a dinner at the end of the first day. For this event, the organizers chose a local seafood establishment recommended by more than one bellman at the hotel. Virtually everyone at the workshop attended the dinner, and all who did found it enjoyable and stimulating.

The continuing success of the TIME workshops is a testimony to the vibrancy of this area of research in AI. We hope that interested readers of this summary of TIME-97 who have not participated in the TIME workshops will consider doing so in the future. Of course, you will need to be able to tolerate the warm breezes and comfortable sunshine typical of Florida in mid May. We are particularly looking forward to next year's TIME workshop, which is planned to be held on Sanibel Island off the West coast of Florida.