CSCE 976, Advanced AI
Scribe notes for Feb 27, 2002

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March 5, 2002

Paper discussed

Title: An Interval-Based Representation of Temporal Knowledge [1].

Author: James Allen

1 The paper

1.1 Introduction

While most work in AI would appear to require some reasoning about time, this problem is typically avoided and delegated to "future research." We cannot ignored this problem any longer if we want to make further progress in the area of problem solving and natural language understanding. A good temporal model needs to provide some general functionalities. The following ones seem particularly important:

1. The model should be able to handle significant imprecision of scale. The temporal relations have absolute sense of time.
2. The model should allow uncertainly. On many situations, the exact relationship between two time intervals is not known, but some constraints are known about how they could be related.
3. The model should have a strong sense of 'now.' The model allows the present moment to change without requiring major changes to the knowledge base.
4. The model should allow a sense of persistence. If P is true now, it will remain true until I notice otherwise.

The author implemented the system in LISP on a VAX 11/780 (CPU:1MHz, MEM:512MB, :-), cory).

1.2 Time points vs. time intervals

In particular, the majority of temporal references are implicitly introduced by tense and the description of how events are related to other events. For example: we found the letter while John was away. This sentence is introducing temporal relations between the time intervals at which the events occurred. The "find letter" event is during the time when John was away.

The most obvious scheme for representing intervals seems to be modeling the endpoints. An interval is an ordered pair of points with begin as the earliest endpoint and end as the latest endpoint. The author does not use time point representation because this scheme is too uniform and does not facilitate structuring the knowledge in a way that is convenient for typical temporal reasoning task. An important relation is the `during` relation. The during relation allows a highly structured representation of time. If P is during t, and t is during T, then P holds during T. The `during` relations allows us to generate hierarchical structures of intervals and enables the reasoning process to remain local in a way that irrelevant facts are never considered.

1.3 Maintaining temporal relations: the simple view

The paper identifies 9 temporal relations possible between two time intervals (actually, there are 13 of them, two are not included here). These relationships are maintained in a network where the nodes represent individual intervals. Each arc represents the relationship between the two intervals (nodes). There may be more than one simple relation on the arc since uncertainty is allowed.

It is assumed that the network always maintains complete information about how the intervals in it could be related. When a new fact adds a constraint about how two intervals could be related, the effects of this constraints should be propagated to the other constraints in the network through transitivity (i.e., constraint inference by composition of constraints). For example, A during B and B is before C, then A must before C. Thus when a new fact is added, its full consequences must be computed.

1.4 Maintaining temporal relations using reference intervals

Since the propagation of constraints throughout the network is costly (i.e., $O(n^3)$ where n is the number of intervals), we need some method to allow us to restrict as much as possible the inferences. The solution proposed by the author is to use one or more *reference intervals*. Each time a relation is added, it is added with respect to a reference intervals. The constraint propagation is then restricted to inferring new relationships between points that share a common reference. The first type of interval useful as a reference is an interval that more or less divides a large set of time intervals into those before and after. Reference intervals can also be used to control inference that is more semantically or pragmatically based.

1.5 Maintaining the present

The method used here is simply to map now onto an interval that is maintained in a similar manner to all other intervals in the system. Using its reference interval, most relations are inferred via the inference interval rather than directly, then updating now to a new interval that has the same reference interval should be easy. When one of the reference intervals ceases to contain the present moment, a new reference interval is selected. The relationship with the higher level reference interval remains constant.

1.6 Persistence of intervals

Persistence of intervals means if fact P is true now, it will remain true until noticed otherwise. Thus, if we let a fact P be indexed by a persistent interval T_p, then testing P later during an interval t will succeed (by assumption) if it is possible that t is during T_p.

2 Comments of students: Questions and answers

Amy: why is the author distinguishing between `during` and `overlaps`, it seem like `during` is a kind of `overlaps`?

Answer: It is more specific, since we know `during` relation has some important attribution.

Amy: is there some bug in page2?

Answer: : Yes, it should be P during t and t during T, hence P during T.

Cory: why did author choose not to implement intervals using time point representation?

Answer: : There are two main representation types of temporal information: interval algebra and time point algebra (with beginning time point and ending time point). Allen works on interval algebra, it only interesting in relation between intervals. But there exists a mapping that reduces point algebra to interval algebra. (Note however that interval algebra is more general, than point algebra.)

Amy: What did the author implement?

Answer: : The author seems to have implemented primitives to declare the intervals and reference intervals, algorithms to do the propagation of the relations between intervals. It looks like kind of KB, you can ask question about relation between any events.

Dan: What did Allen use this algebra for?

Answer: : Allan uses it to do planning. Interval algebra for time (these 13 relations and propagation between them) is one of his most important works. This is very useful for NLP, VLSI simulation, etc.

Tibor: I don't see how he applies constraint propagation to this problem. what are my variables, what are their values?

Answer: : This is not a CSP in the purest kind: the variables are intercals the relations are constraints, there are no values for the variables (there is no absolute reference point for time). The constraint propagation is about restricting the time relations in each constraint.

Tibor: The author states that the "present is continually moving into the future." How does this work? shouldn't the present move into the past?

Answer: Since the clock always keep going, then the present is continually moving into "the future." The author's point is that updating of now should not involve a large-scale reorganization of the data base.

References

[1] James F. Allen. An interval based representation of temporal knowledge. In *Proc. of the 7th IJCAI*, pages 221–226, Vancouver, Canada, 1981.