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A Time Calculus for Natural Language

In most of the practical systems incorporating automatic natural language analysis, real time has long been a forgotten dimension. For the few that utilize it, it is often oversimplified and not flexible enough for sophisticated reasoning required in more advanced tasks. The problem is twofold: the nuances of time manifested in natural language requires a rich yet compositional representation, and the need for advanced reasoning demands a more inference-ready encoding of time.

Several previous works have explored the reasoning aspect of time, such as the works on various temporal logics and temporal constraint problems, and also on annotating and representing time in natural language, such as the recent development of the DAML Ontology of Time, Timex2 and TimeML. However, we feel that the need from both ends of the spectrum has not been fully satisfied.

In this work we propose a time calculus for natural language, from a setting of constraint satisfaction problems (CSP). Architecturally, real-world calendars are modeled as the lowest level CSP, and provide the basic vocabularies for meaning composition. Temporal expressions are then captured using a typed formal language, where the phenomena such as granularity conversion and re-interpretation are handled via type coercion. With the proposed operators and relations, both qualitative and quantitative constraints among various temporal entities can then be expressed, and the resulting temporal constraint satisfaction problem (TCSP) is solved using a modified all-pairs shortest path algorithm. As with the previous works on TCSP, this formulation will enable the answering of various interesting temporal queries.