Annotating, Extracting and Reasoning About Time and Events

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Abstract. The main focus of the Dagstuhl seminar 05151 was on TimeML-based temporal annotation and reasoning. We were concerned with three main points: how effectively can one use the TimeML language for consistent annotation, determining how useful such annotation is for further processing, and determining what modifications should be applied to the standard to make it more useful for applications such as question-answering and information retrieval.

1 Introduction

Today's information extraction systems are capable of reliably extracting named entities such as PERSON or COMPANY names and LOCATIONS. Newspaper articles and other natural language texts, however, describe much more information between such entities than this. In particular, the underlying temporal relations between events would be very valuable for summarization system that produced summaries of developing stories. In order to provide a summary of a developing news story, for example, sequences of events need to be presented in a chronological and coherent way. A system that can produce such a summary would need to extract a time stamp for each event and to order the extracted events according to the time line. Current summarization systems are not able to do this or can offer only a rough approximation of the temporal information.

Such a summarization system is one example of future IE system that would require reliable temporal information in order to allow for temporal reasoning capabilities. Other systems that would benefit from temporal information include: Question-Answering systems, medical documentation systems, and legal reasoning systems.

Hence, a crucial first step toward the automatic extraction of information from texts is the capacity to identify what events are being described and to make explicit when these events occurred and which temporal relations hold

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among them. There has recently been a renewed interest in making use of this kind of temporal and event-based information, with a wide variety of proposals and applications having been presented at recent conferences and workshops. [1,2,3,4,5].

Extracting temporal information from natural-language text is not trivial, since much of the temporal information conveyed in a natural language text is left implicit. Significant recent work has focused on developing schemata for making this information explicit, typically via annotation. An important result of contemporary research has been the adoption of a *de facto* standard for time and event annotation: TimeML [3,4,6].[1] This XML-based markup language is specifically designed for annotating texts with tags that make explicit the temporal and event-based information conveyed by the text, and has been adopted by a number of researchers in this domain. Much of our seminar was concerned with issues specific to this annotation scheme.

There are three basic types of tags used within the TimeML language:

`TIMEX` tags are used to annotate temporal expressions and provide them with a normalized value (e.g.,

```
<TIMEX tid="t1" val="2005-04-21">April 21st, 2005</TIMEX>
```

`EVENT` tags are used to annotate event expressions, providing "hooks" to relate them to other events and times:

```
<EVENT eid="ei">opened</EVENT>
```

`TLINK` tags indicate the temporal relations that hold between times and events (e.g. *the stock market opened on April 21st, 2005 at 10:00pm*):

```
<TLINK event="e1" relatedTime="t1" relation="IS_INCLUDED"/>
```

Other tags are used to capture more subtle semantic relations. `SLINK` tags, for example, are used to indicate various kinds of subordination relations, such as *reported speech*, in *The spokesman said the bomb injured 20 people*, or intensional contexts, such as in *Investors hoped that the stock market would open on April 21st, 2005 at 10:00pm.* Finally, `ALINK` tags indicate the aspect (or phase) of an event, as in *The market began to fall suddenly.* A corpus of 183 TimeML annotated documents (*TimeBank*) has been released by the LDC, and can be browsed and downloaded at `timeml.org`.

The seminar took place at Schloss Dagstuhl from 10. April - 15. April 2005. The central goal of the seminar was to consolidate the insights that have been made in recent years and to identify and address issues concerning annotation, temporal reasoning, and event identification that remain unresolved.

The various talks presented ranged from addressing the logical foundations of temporal reasoning to discussing the practical aspects of computing temporal information:

[1] To promote TimeML as a more formal standard, it has recently been adopted as a candidate for an ISO standard, and is currently being reviewed in this capacity.

1. Branimir Boguraev (IBM Research, USA)
   TimeBank-driven TimeML Analysis
2. Frank Schilder (Thomson R&D, USA)
   Temporal Information Extraction from Legal Documents
3. Andrea Setzer (University of Sheffield, GB)
   TimeML in a Medical Application
4. Jerry Hobbs (USC/ISI - Marina del Rey, USA)
   A Temporal Ontology for the Semantic Web
5. Lauri Karttunen and Annie Zaenen (PARC - Palo Alto, USA)
   Veridicity and Commitment?
6. Laure Vieu (LOA -Trento, I)
   Scope of Temporal Adverbials in Discourse
7. David Ahn (University of Amsterdam, NL)
   Towards Task-based Temporal Extraction and Recognition
8. Benjamin Han (CMU - Pittsburgh, USA)
   Understanding Times: An Constraint-based Approach
9. Tom Bittner (Univ. des Saarlandes, D)
   Approximate Qualitative Temporal Reasoning
10. Mark Steedman (University of Edinburgh, GB)
    The Calculus of Affordance
11. Marc Verhagen (Brandeis University, USA)
    Drawing TimeML Relations
12. Hans-Jürgen Ohlbach (Universität München, D)
    Computational Treatment of Temporal Notions the CTTN System
13. Rob Gaizauskas (University of Sheffield, GB)
    Getting Closure: Vagueness and Disjunction in TimeML
14. Graham Katz (University of Osnabrück, D)
    The Semantics of TimeML
15. James Pustejovsky (Brandeis University, USA)
    Event Arguments in TimeML
16. Ian Pratt-Hartmann (Manchester University, GB)
    Temporal Prepositions and their Logic
17. Inderjeet Mani (MITRE, USA)
    Chronoscopes: A theory of Underspecified Temporal Relations

This book contains selected papers that are further developments of the work presented at the workshop. The papers are representative for a set of important sub-areas identified by the seminar where progress has to be made in order to advance this field.

Issues Concerning Temporal Annotation. An increasingly important research question is concerned with the representation of temporal information, either while carrying out the annotation or for the purpose of representing it. Firstly, the annotation task can be made more reliable if the annotated temporal relations are easily viewable without burdening the annotator with too many details. Secondly, the resulting temporal information needs to be presented to a viewer in

a understandable way. Previous work using a graph representation were already a step forward compared to simply adding temporal information to the XML tags. However, a graph annotation used for TANGO could produce too many links, because all implicit temporal information would be made explicit. In oder to deal with this representational problem, Marc Verhagen proposes a graphical representation called TBox that leaves some temporal information implicit by reducing the number of explicitly presented relations. This representation reduces the number of inconsistencies that may be introduced by a more cluttered representation of temporal information in an annotation tool.

Linguistic Analysis of Temporal Expressions. In this volume, Janet Hitzeman provides an account on the semantics of initial and sentence final temporal adverbials. She compares four different texts in order to evaluate whether text-type has an effect on the position (and interpretation) of temporal adverbials.

At the seminar, Laure Vieu presented an analysis of Locating Adverbials (LAs) such as *un peu plus tard* or *ce matin* (a little later, this morning) when they are dislocated to the left of the sentence (IP Adjuncts cases). She showed evidence that LAs seem to play an important part in structuring discourse. Lauri Karttunen and Annie Zaenen illustrate some cases of conventional implicature and show how they indicate an author's commitment to the truth of his/her statements and briefly state the importance of these distinctions for Information Extraction.

Learning from Annotations. Since the compilation of TimeBank, work on automatically learning the temporal relations has been enabled. Learning the temporal relations between the time stamp and events as well as between adjacent events in a text have recently been investigated within the SemEval competition. The TempEval task used the TimeBank corpus [5].

Within this collection, Bran Boguraev and Rie Kubota Ando present an in-depth analysis of TimeBank and discus experimental results on TimeML-compliant parsing via a blend of finite-state approaches with machine learning techniques.

Similarly, David Ahn, Joris van Rantwijk and Maarten de Rijke [7] published a follow-up paper of David Ahn's talk at the Dagstuhl seminar describing tagging temporal expressions via a cascaded approach combining several machine learning classifiers. Their experiments on the TERN 2004 data show that the cascaded machine-learning approach requires a much smaller number of composition rules for the derivation of the ISO-time stamps than competing approaches with comparable results.

New Domains. Talks at the seminar also identified interesting new domains for time and event annotation. Frank Schilder's paper discusses what kind of legal documents (legal narratives, transactional documents, statutes) may benefit from temporal information extraction and presents a prototype for extracting temporal information from U.S. statutes.

At the seminar, two other domains were discussed. Andrea Setzer presented a project from the medical domain.[2] In this project temporal information from patient notes dictated by doctors is to be extracted and mapped onto a database containing records of interventions (e.g., surgery) and investigations (e.g., X-RAY) performed on the patient. Ben Han investigated another domain that is different from the standard news texts TimeBank consists of (viz., email messages). Subsequent work by him was published at NAACL 2006 [8].

Time Logic. Practical tools for reasoning with temporal information were presented at the seminar by Benjamin Han and Hans-Jürgen Ohlbach. They presented implementations that do reasoning with temporal information, such as computing the current date "plus 2 months" (*two months from today*). Their implementations are written in Python (Han) and C++ (Ohlbach). Ohlbach expands on this work in the paper in this volume.

Graham Katz's paper provides a model-theoretic semantics for TimeML, closely based on Discourse Representation Theory. He addresses the problems of semantic scope, providing a second-order semantics that simulates semantic scope, and presents a very basic treatment of some of the non-extensional aspects of TimeML, namely the modality and the SLINK tags.

Ian Pratt-Hartmann published a paper based on his talk at the Seventh International Workshop on Computational Semantics [9]. His paper is concerned with the translation from TimeML annotation to temporal interval logic. Jerry Hobbs' presentation at the workshop was concerned with the annotation of durations of event descriptions in text. This work was published subsequently at different conferences and workshops (e.g., [10]). Mark Steedman analyzes temporal semantics for natural language in terms of a calculus developed for planning and reasoning about action. He proposed an event calculus based on Linear Dynamic Logic, and on instantaneous changes rather than intervals.

Reasoning. An important next step in this research area will involve techniques for reasoning with temporal information.

James Pustejovsky, Jessica Littman and Roser Saurí discuss the issue of whether TimeML should incorporate all of a verb's arguments into the markup specification language. They propose that the language of TimeML should make reference only to event arguments, and not to all verbal arguments. TimeML already makes reference to considerable argument structure in subordinating and aspectual contexts. These event-event relations between the predicate and an argument cover a large number of the events selected for by predicates. Most of those not covered, it is argued, are lexical discourse markers, such as *lead to*, and should be handled by a new LINK-type, called a DLINK (discourse link).

Inderjeet Mani's paper focuses on an important component of temporal reasoning that has been largely neglected: granularity. The author introduces an abstract device called chronoscopes that allows temporal abstraction over events and temporal relations depending on the chosen time granularity.

[2] `http://nlp.shef.ac.uk/clef/`

Another talk during the seminar was also concerned with granularity. Tom Bittner describes representation and reasoning methods taking the limits of our knowledge explicitly into account. For example, *happened yesterday* does not mean that x started at *12 am* and ended *0 pm*. He proposes an approach that describes the temporal location of events and processes as approximate and "rough" in nature, rather than exact and crisp. At the seminar, Rob Gaizauskas also discussed different approaches to representing the temporal information encoded in TimeML. He investigates how vague temporal information can be presented.

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