SUTIME: A Library for Recognizing and Normalizing Time Expressions

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Abstract

We describe SUTIME, a temporal tagger for recognizing and normalizing temporal expressions in English text. SUTIME is available as part of the Stanford CoreNLP pipeline and can be used to annotate documents with temporal information. It is a deterministic rule-based system designed for extensibility. Testing on the TempEval-2 evaluation corpus shows that this system outperforms state-of-the-art techniques.

Keywords: temporal tagger, time normalization, pattern matching

1. Introduction

The importance of modeling temporal information is increasingly apparent in natural language applications, such as information extraction and question answering. For instance, in relation extraction, it is not sufficient to just extract simple relations like *President(U.S.A, George Walker Bush)*. Rather, one would also need to extract fluents that capture the temporal range over which such relations hold. Given the sentence

George Walker Bush (born July 6, 1946) is an American politician who served as the 43rd President of the United States from 2001 to 2009.

we can extract the following temporal information about when George Bush was born and when he was president:

	Expression	Type	Normalized
Birth	July 6, 1946	DATE	1946-07-06
Pres.	from 2001 to 2009	RANGE	2001/2009

Extracting such temporal information requires the ability to recognize temporal expressions, and to convert them from text to a normalized form that is easy to process. Systems that extract temporal expressions are known as *temporal taggers*. In this paper, we present SUTIME, a system for extracting and normalizing temporal expressions.

2. System Description

SUTIME is a rule-based temporal tagger built on regular expression patterns. Temporal expressions are bounded in their complexity, so many of them can be captured using finite automata. As shown by systems such as FASTUS (Hobbs et al., 1997), a cascade of finite automata can be very effective at extracting information from text. With SUTIME, we follow a similar staged strategy of (i) building up patterns over individual words to find numerical expressions; then (ii) using patterns over words and numerical expressions to find simple temporal expressions; and finally (iii) forming composite patterns over the discovered temporal expressions.

In NLP applications, text is usually first tokenized and annotated, making it convenient to specify regular expressions over the tokens. The resulting regular expressions

can be more concise and easier to understand, manipulate and modify than traditional regular expressions over strings. Regular expressions over tokens facilitate access to additional features, such as parts-of-speech and named entity tags. With this approach, adding new rules to SUTIME is simple, by design.

We provide SUTIME as a Java library, implemented as an annotator in the Stanford CoreNLP pipeline;[1] its main features are described below:

Extraction of temporal expressions from text: Given tokenized English text, SUTIME finds temporal expressions and outputs annotations for further manipulation and interpretation. Its output includes annotations in the form of TIMEX3 tags. TIMEX3 is part of the TimeML annotation language (Pustejovsky et al., 2003) for markup of events, times and their temporal relations in documents. To better capture temporal information found in natural language, the value attribute of TIMEX3 tags extends the ISO 8601[2] standard. For temporal expressions not covered by this specification, we introduce additional attributes.

Representation of temporal objects as Java classes: Natural language uses many kinds of temporal expressions. SUTIME provides tools to map them to logical representations and data structures that are easier to handle programmatically. For interoperability, our representations are convertible to Joda-Time[3] classes.

Resolution of temporal expressions with respect to a reference date: When processing natural language text, one often has to work with expressions that refer to a relative time (e.g., *last Friday*). Determining the actual date to which such expressions refer requires a reference date, on which the statement was made. SUTIME uses document dates as references. For example, for a document from **2011-09-19**, SUTIME would resolve the date referred to by *last Friday* as **2011-09-16**. But there could be confusion about the time point to which expressions refer: e.g., from a date like

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[1] nlp.stanford.edu/software/corenlp.shtml
[2] www.iso.org/iso/date_and_time_format
[3] Joda-Time — joda-time.sourceforge.net — is a comprehensive Java API for working with dates and times.

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Computational Science – ICCS 2024 Leonardo Franco,Clélia de Mulatier,Maciej Paszynski,Valeria V. Krzhizhanovskaya,Jack J. Dongarra,Peter M. A. Sloot,2024-06-26 The 7 volume set LNCS 14832 14838 constitutes the proceedings of the 24th International Conference on Computational Science ICCS 2024 which took place in Malaga Spain during July 2 4 2024 The 155 full papers and 70 short papers included in these proceedings were carefully reviewed and selected from 430 submissions They were organized in topical sections as follows Part I ICCS 2024 Main Track Full Papers Part II ICCS 2024 Main Track Full Papers Part III ICCS 2024 Main Track Short Papers Advances in High Performance Computational Earth Sciences Numerical Methods Frameworks and Applications Artificial Intelligence and High Performance Computing for Advanced Simulations Part IV Biomedical and Bioinformatics Challenges for Computer Science Computational Health Part V Computational Optimization Modelling and Simulation Generative AI and Large Language Models LLMs in Advancing Computational Medicine Machine Learning and Data Assimilation for Dynamical Systems Multiscale Modelling and Simulation Part VI Network Models and Analysis From Foundations to Artificial Intelligence Numerical Algorithms and Computer Arithmetic for Computational Science Quantum Computing Part VII Simulations of Flow and Transport Modeling Algorithms and Computation Smart Systems Bringing Together Computer Vision Sensor Networks and Artificial Intelligence Solving Problems with Uncertainties Teaching Computational Science *Computational Linguistics and Intelligent Text Processing* Alexander Gelbukh,2013-03-12 This two volume set consisting of LNCS 7816 and LNCS 7817 constitutes the thoroughly refereed proceedings of the 13th International Conference on Computer Linguistics and Intelligent Processing CICLING 2013 held on Samos Greece in March 2013 The total of 91 contributions presented was carefully reviewed and selected for inclusion in the proceedings The papers are organized in topical sections named general techniques lexical resources morphology and tokenization syntax and named entity recognition word sense disambiguation and coreference resolution semantics and discourse sentiment polarity subjectivity and opinion machine translation and multilingualism text mining information extraction and information retrieval text summarization stylometry and text simplification and applications **Innovations in Bio-Inspired Computing and Applications** Ajith Abraham,Niketa Gandhi,Millie Pant,2019-05-21 This book highlights recent research on bio inspired computing and its various innovative applications in Information and Communication Technologies It presents 50 high quality papers from the 9th International Conference on Innovations in Bio Inspired Computing and Applications IBICA 2018 and 7th World Congress on Information and Communication Technologies WICT 2018 which was held at Toc H Institute of Science and Technology TIST on December 17 19 2018 IBICA WICT 2018 was a premier conference and brought together researchers engineers and practitioners whose work involved bio inspired computing computational intelligence and their applications in information security real world contexts etc Including contributions by authors from 22 countries the book offers a valuable reference

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volume set LNAI 16093 16094 constitutes the proceedings of the 19th European Conference on Logics in Artificial Intelligence JELIA 2025 held in Kutaisi Georgia during September 1 4 2025 The 39 full papers and 5 short papers included in this volume were carefully reviewed and selected from 108 submissions They were organized in the following topics Part I Special Track Logics for Explainable and Trustworthy AI Argumentation Constraint Satisfaction and Optimization Deontic Reasoning Description Logics and Ontological Reasoning Higher order and Non classical Logics Logic Programming and Answer Set Programming Part II Non monotonic Reasoning and Belief Change Propositional Reasoning QBF and Satisfiability Problems Temporal Reasoning Theorem Proving   Domain-Sensitive Temporal Tagging Jannik Strötgen,Michael Gertz,2016-07-28 This book covers the topic of temporal tagging the detection of temporal expressions and the normalization of their semantics to some standard format It places a special focus on the challenges and opportunities of domain sensitive temporal tagging After providing background knowledge on the concept of time the book continues with a comprehensive survey of current research on temporal tagging The authors provide an overview of existing techniques and tools and highlight key issues that need to be addressed This book is a valuable resource for researchers and application developers who need to become familiar with the topic and want to know the recent trends current tools and techniques as well as different application domains in which temporal information is of utmost importance Due to the prevalence of temporal expressions in diverse types of documents and the importance of temporal information in any information space temporal tagging is an important task in natural language processing NLP and applications of several domains can benefit from the output of temporal taggers to provide more meaningful and useful results In recent years temporal tagging has been an active field in NLP and computational linguistics Several approaches to temporal tagging have been proposed annotation standards have been developed gold standard data sets have been created and research competitions have been organized Furthermore some temporal taggers have also been made publicly available so that temporal tagging output is not just exploited in research but is finding its way into real world applications In addition this book particularly focuses on domain specific temporal tagging of documents This is a crucial aspect as different types of documents e g news articles narratives and colloquial texts result in diverse challenges for temporal taggers and should be processed in a domain sensitive manner

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