

# 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:

	<i>Expression</i>	<i>Type</i>	<i>Normalized</i>
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;<sup>1</sup> 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<sup>2</sup> 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<sup>3</sup> 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

<sup>1</sup>[nlp.stanford.edu/software/corenlp.shtml](http://nlp.stanford.edu/software/corenlp.shtml)

<sup>2</sup>[www.iso.org/iso/date\\_and\\_time\\_format](http://www.iso.org/iso/date_and_time_format)

<sup>3</sup>Joda-Time — [joda-time.sourceforge.net](http://joda-time.sourceforge.net) — is a comprehensive Java API for working with dates and times.

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## **Table of Contents Sutime A Library For Recognizing And Normalizing Time**

1. Understanding the eBook Sutime A Library For Recognizing And Normalizing Time
  - The Rise of Digital Reading Sutime A Library For Recognizing And Normalizing Time
  - Advantages of eBooks Over Traditional Books
2. Identifying Sutime A Library For Recognizing And Normalizing Time
  - Exploring Different Genres
  - Considering Fiction vs. Non-Fiction
  - Determining Your Reading Goals
3. Choosing the Right eBook Platform
  - Popular eBook Platforms
  - Features to Look for in an Sutime A Library For Recognizing And Normalizing Time
  - User-Friendly Interface
4. Exploring eBook Recommendations from Sutime A Library For Recognizing And Normalizing Time
  - Personalized Recommendations
  - Sutime A Library For Recognizing And Normalizing Time User Reviews and Ratings
  - Sutime A Library For Recognizing And Normalizing Time and Bestseller Lists

5. Accessing Sutime A Library For Recognizing And Normalizing Time Free and Paid eBooks
  - SUTIME A LIBRARY FOR RECOGNIZING AND NORMALIZING TIME Public Domain eBooks
  - SUTIME A LIBRARY FOR RECOGNIZING AND NORMALIZING TIME eBook Subscription Services
  - SUTIME A LIBRARY FOR RECOGNIZING AND NORMALIZING TIME Budget-Friendly Options
6. Navigating SUTIME A LIBRARY FOR RECOGNIZING AND NORMALIZING TIME eBook Formats
  - ePub, PDF, MOBI, and More
  - SUTIME A LIBRARY FOR RECOGNIZING AND NORMALIZING TIME Compatibility with Devices
  - SUTIME A LIBRARY FOR RECOGNIZING AND NORMALIZING TIME Enhanced eBook Features
7. Enhancing Your Reading Experience
  - Adjustable Fonts and Text Sizes of SUTIME A LIBRARY FOR RECOGNIZING AND NORMALIZING TIME
  - Highlighting and Note-Taking SUTIME A LIBRARY FOR RECOGNIZING AND NORMALIZING TIME
  - Interactive Elements SUTIME A LIBRARY FOR RECOGNIZING AND NORMALIZING TIME
8. Staying Engaged with SUTIME A LIBRARY FOR RECOGNIZING AND NORMALIZING TIME
  - Joining Online Reading Communities
  - Participating in Virtual Book Clubs
  - Following Authors and Publishers SUTIME A LIBRARY FOR RECOGNIZING AND NORMALIZING TIME
9. Balancing eBooks and Physical Books SUTIME A LIBRARY FOR RECOGNIZING AND NORMALIZING TIME
  - Benefits of a Digital Library
  - Creating a Diverse Reading Collection SUTIME A LIBRARY FOR RECOGNIZING AND NORMALIZING TIME
10. Overcoming Reading Challenges
  - Dealing with Digital Eye Strain
  - Minimizing Distractions
  - Managing Screen Time
11. Cultivating a Reading Routine SUTIME A LIBRARY FOR RECOGNIZING AND NORMALIZING TIME
  - Setting Reading Goals SUTIME A LIBRARY FOR RECOGNIZING AND NORMALIZING TIME
  - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of SUTIME A LIBRARY FOR RECOGNIZING AND NORMALIZING TIME
  - Fact-Checking eBook Content of SUTIME A LIBRARY FOR RECOGNIZING AND NORMALIZING TIME
  - Distinguishing Credible Sources
13. Promoting Lifelong Learning

- Utilizing eBooks for Skill Development
  - Exploring Educational eBooks
14. Embracing eBook Trends
- Integration of Multimedia Elements
  - Interactive and Gamified eBooks

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