Parsing Time

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Natural Language Processing

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Example

Don’t worry, June 5 is next week – there’s still a few days
Example

*Don’t worry, June 5 is next week – there’s still a few days*

**Detection** Finding temporal *phrases* in a sentence.
Example

Don’t worry, June 5 is next week – there’s still a few days

Detection  Finding temporal phrases in a sentence.

Interpretation  Finding the grounded meaning of a phrase
Don’t worry, June 5 is next week – there’s still a few days

Detection  Finding temporal phrases in a sentence.

Interpretation  Finding the grounded meaning of a phrase
But, often incomplete information
Example

Don’t worry, June 5 is next week – there’s still a few days

[2012-06-02]  6/05/12  6/03/12–6/09/12  ∼1D

Detection  Finding temporal phrases in a sentence.

Interpretation  Finding the grounded meaning of a phrase
But, often incomplete information
Incorporate a reference time
Don’t worry, June 5 is next week – there’s still a few days

6/5 WXX \[ \sim 1D \]

[ 2012-06-02 ] 6/05/12 6/10/12-6/16/12 \[ \sim 1D \]

**Detection**  Finding temporal *phrases* in a sentence.

**Interpretation**  Finding the grounded *meaning* of a phrase
But, often incomplete information
Incorporate a *reference time*
Sneak Peek: ambiguity in *next week*
**Time In Information Extraction**

**News**

Beginning more than **seven hours earlier**, the space station’s robotic arm detached the 14-foot long Dragon [spacecraft]

Benjamin Franklin Federal Savings and Loan Association said it plans to restructure in the wake of a **third-quarter loss**
News

Beginning more than seven hours earlier, the space station’s robotic arm detached the 14-foot long Dragon [spacecraft]

Benjamin Franklin Federal Savings and Loan Association said it plans to restructure in the wake of a third-quarter loss

Communication

Actually I am on vacation the last three weeks of November

I have some time available at the end of next week
Motivation

Current approaches

Collection of hand-coded rules

Mani & Wilson 2000; Strötgen and Gertz 2010; Chang and Manning (2012)
Motivation

Current approaches
Collection of hand-coded rules

Downsides
Rigid
Syntax: last Friday the 13th

Mani & Wilson 2000; Strötgen and Gertz 2010; Chang and Manning (2012)
Motivation

Current approaches
Collection of hand-coded rules

Downsides
Rigid
Syntax: last Friday the 13th
Pragmatics: when is last Sunday?

Mani & Wilson 2000; Strötgen and Gertz 2010; Chang and Manning (2012)
Motivation

Current approaches
Collection of hand-coded rules

Downsides
Rigid
Syntax: last Friday the 13th
Pragmatics: when is last Sunday?

Rule engineering challenge
Always more rules: 7 days prior, the previous 7 days
\[\text{/the/ /past\mid last/ (?: ($NUM) /to\mid -/) ? ($NUM) ? ($TEUNITS)}\]
\[\text{/the/ /next\mid following/ (?: ($NUM) /to\mid -/) ? ($NUM) ? ($TEUNITS)}\]
\[\text{/another/ (?: ($NUM) /to\mid -/) ? ($NUM) ? ($TEUNITS)}\]
\[
\text{Mani & Wilson 2000; Strötgen and Gertz 2010; Chang and Manning (2012)}
\]
System

Input \((w,t)\) ( phrase, reference )
System

Input \((w, t)\) \((Last \ Friday \ the \ 13th, \ 2012-06-05)\)
System

Input \((w,t)\) (Last Friday the 13th, 2012-06-05)

Output \(\tau^*\) normalized time
System

Input \((w,t)\) \((\textit{Last Friday the 13th}, \ 2012-06-05)\)

Output \(\tau^*\)  \(2012-01-13\)
System

Input \((w, t)\) ( \emph{Last Friday the 13th}, \(2012-06-05\) )

\[\text{Latent parse } R\]

Output \(\tau^*\) \(2012-01-13\)
Input \((w,t)\) (Last Friday the 13th, 2012-06-05)

\[
\text{moveLeft1}(\text{FRI} \cap 13^{\text{th}})
\]

\[
\text{moveLeft1}(-)
\]

\[
\text{last}
\]

\[
\text{FRI} \cap 13^{\text{th}}
\]

\[
\text{Friday}
\]

\[
\text{Nil}_{\text{the}}
\]

\[
\text{the}
\]

\[
13^{\text{th}}
\]

Output \(\tau^*\) 2012-01-13
Motivation

Our Model

Gives informative probability
Motivation

Our Model

Gives informative probability

Handle syntactic ambiguity

[Last Friday] [the 13\textsuperscript{th}] and [last] [Friday the 13\textsuperscript{th}]
Motivation

Our Model

Gives informative probability
Handle syntactic ambiguity

[Last Friday] [the 13\textsuperscript{th}] and [last] [Friday the 13\textsuperscript{th}]

Handle pragmatic ambiguity

Could we meet on Tuesday?
Motivation

Our Model

Gives informative probability
Handle syntactic ambiguity

[Last Friday] [the $13^{th}$] and [last] [Friday the $13^{th}$]

Handle pragmatic ambiguity

Could we meet on Tuesday?

Plays nice in larger systems
Motivation

Our Model

Gives informative probability
Handle syntactic ambiguity

[Last Friday] [the 13th] and [last] [Friday the 13th]
Handle pragmatic ambiguity
Could we meet on Tuesday?
Plays nice in larger systems

Elegant representation of time
Motivation

Our Model

Gives informative probability
Handle syntactic ambiguity

[Last Friday] [the 13th] and [last] [Friday the 13th]
Handle pragmatic ambiguity
Could we meet on Tuesday?
Plays nice in larger systems

Elegant representation of time

Language/domain flexible
Learn any structure seen in training
Motivation

Our Model

Gives informative probability
Handle syntactic ambiguity

[Last Friday] [the 13\textsuperscript{th}] and [last] [Friday the 13\textsuperscript{th}]

Handle pragmatic ambiguity

Could we meet on Tuesday?

Plays nice in larger systems

Elegant representation of time

Language/domain flexible

Learn any structure seen in training

Last Sunday and domingo pasado
Comparison To Lambda Calculus

Parallels to semantic parsing

\[ \lambda x. \text{flight}(x) \land \text{to}(x, \text{boston}) \]

\[ \lambda x. \text{flight}(x) \quad \lambda f. \lambda x. f(x) \land \text{to}(x, \text{boston}) \]

\[ \lambda y. \lambda f. \lambda x. f(x) \land \text{to}(x, y) \quad \text{boston} \]

\[ \lambda y. \lambda f. \lambda x. f(x) \land \text{to}(x, y) \quad \downarrow \]

\[ \text{to} \quad \text{Boston} \]

Zettlemoyer & Collins 2005/2007; Liang et al. 2011
Comparison To Lambda Calculus

Parallels to semantic parsing

\[ \lambda x. \text{flight}(x) \land \text{to}(x, \text{boston}) \]

\[ \lambda x. \text{flight}(x) \]

\[ \lambda f. \lambda x. f(x) \land \text{to}(x, \text{boston}) \]

\[ \lambda y. \lambda f. \lambda x. f(x) \land \text{to}(x, y) \]

\[ \text{flights} \]

\[ \text{to} \]

\[ \text{boston} \]

\[ \text{Boston} \]

\[ \text{moveLeft1} \left( \text{Friday} \cap 13^{\text{th}} \right) \]

\[ \text{moveLeft1}(-) \]

\[ \text{last} \]

\[ \text{FRI} \]

\[ \text{13}^{\text{th}} \]

\[ \text{Nil} \]

\[ \text{the} \]

\[ \text{13}^{\text{th}} \]

Zettlemoyer & Collins 2005/2007; Liang et al. 2011
Comparison To Lambda Calculus

Option 1: bootstrap from parse

\[
\lambda x. \text{flight}(x) \land \text{to}(x, \text{boston})
\]

\[
\lambda x. \text{flight}(x) \quad \lambda f. \lambda x. f(x) \land \text{to}(x, \text{boston})
\]

\[
\lambda y. \lambda f. \lambda x. f(x) \land \text{to}(x, y) \quad \text{boston}
\]

\[
\lambda y. \lambda f. \lambda x. f(x) \land \text{to}(x, y) \quad \text{Boston}
\]

\[
\text{moveLeft1}(\text{FRI} \cap \text{13th})
\]

\[
\text{moveLeft1}(\neg) \quad \text{FRI} \cap \text{13th}
\]

\[
\text{last} \quad \text{FRI}
\]

\[
\text{to} \quad \text{Friday}
\]

\[
\text{to} \quad \text{Nil}
\]

\[
\text{to} \quad \text{the}
\]

\[
\text{to} \quad \text{13th}
\]

Zettlemoyer & Collins 2005/2007; Liang et al. 2011
Comparison To Lambda Calculus

Option 1: bootstrap from parse

\[ \lambda x. \text{flight}(x) \land \text{to}(x, \text{boston}) \]

\[ \lambda x. \text{flight}(x) \]

\[ \lambda f. \lambda x. f(x) \land \text{to}(x, \text{boston}) \]

\[ \lambda y. \lambda f. \lambda x. f(x) \land \text{to}(x, y) \]

\[ \text{flights} \]

\[ \text{boston} \]

\[ \text{Boston} \]

\[ \text{moveLeft1}(\text{FRI} \cap \text{13}^{\text{th}}) \]

\[ \text{moveLeft1}(\text{FRI} \cap \text{13}^{\text{th}}) \]

\[ \text{moveLeft1}(\text{FRI} \cap \text{13}^{\text{th}}) \]

\[ \text{last} \]

\[ \text{Friday} \]

\[ \text{the} \]

\[ \text{Nil} \]

Zettlemoyer & Collins 2005/2007; Liang et al. 2011
Comparison To Lambda Calculus

**Option 2**: bootstrap from grounded interpretation

\[
\lambda x. \text{flight}(x) \land \text{to}(x, \text{boston})
\]

\[
\lambda f. \lambda x. \neg \text{flight}(x) \land \text{to}(x, \text{boston})
\]

\[
\lambda y. \lambda f. \lambda x. \neg \text{flight}(x) \land \text{to}(x, y)
\]

\[
\text{to}
\]

\[
\text{flights}
\]

\[
\text{Delta 3871}
\]

\[
2012-01-13
\]

\[
2012-06-05
\]

\[
\text{moveLeft1(} \neg \text{FRI} \cap 13^{\text{th}} \text{)}
\]

\[
\text{moveLeft1(} \text{Friday} \cap 13^{\text{th}} \text{)}
\]

\[
\text{last}
\]

\[
\text{to}
\]

\[
\text{Boston}
\]

\[
\text{Zettlemoyer & Collins 2005/2007; Liang et al. 2011}
\]
Latent Parse

Expressions parse compositionally
Latent Parse

Expressions parse compositionally

last 2 days
Expressions parse compositionally

last 2 days
Latent Parse

Expressions parse compositionally

last 2 days
Latent Parse

Expressions parse compositionally

last 2 days

\[ \text{last} \times 2 \text{ DAYS} \]

\[ f : \text{Duration} \rightarrow \text{RangetakeLeft}(\text{--}) \]
Expressions parse compositionally

last 2 days

```
takeLeft(2 \times \text{DAY})
```

```
takeLeft(-)
```

```
2 \times \text{DAY}
```

```
last
```

```
2
```

```
2
```

```
days
```

```
8
```
Expressions parse compositionally

\[ \text{takeLeft}(2 \times \text{DAY}) \]

\[ \text{last} \]

\[ \text{2} \times \text{DAY} \]

\[ \text{last} \]

\[ \text{2} \]

\[ \text{2} \text{days} \]

\[ [2012-06-05] \rightarrow 2012-06-03 - 2012-06-05 \]
Latent Parse

Nonterminals become very sparse
Latent Parse

Nonterminals become very sparse

Consider: last 7 days, last 3 months, etc.
Nonterminals become very sparse

Consider: *last 7 days*, *last 3 months*, etc.

**Solution:** Group nonterminals based on *types*
Nonterminals become very sparse

Consider: last 7 days, last 3 months, etc.

Solution: Group nonterminals based on types

\[
\text{takeLeft}(2 \times \text{DAY})
\]

- takeLeft(−)
  - last
  - 2 \times \text{DAY}
    - 2
      - 2
        - \text{days}
Latent Parse

Nonterminals become very sparse
Consider: last 7 days, last 3 months, etc.
Solution: Group nonterminals based on types

\[
\text{takeLeft}(2 \times \text{DAY})
\]

\[
\text{takeLeft}(-) \rightarrow \text{last} \rightarrow 2 \times \text{DAY} \rightarrow 2 \rightarrow \text{Duration} \rightarrow 2 \rightarrow \text{days}
\]
Latent Parse

Nonterminals become very sparse
Consider: last 7 days, last 3 months, etc.
Solution: Group nonterminals based on types

takeLeft(2 × \text{DAY})

takeLeft(−) \quad 2 × \text{DAY}

last

Number \quad Duration

2 \quad days
Nonterminals become very sparse
Consider: last 7 days, last 3 months, etc.

Solution: Group nonterminals based on types

\[ f : \text{Duration} \rightarrow \text{Range} \]

\[ \text{Duration} \]

\[ \text{Number} \]

\[ 2 \]

\[ \text{days} \]
Nonterminals become very sparse

Consider: last 7 days, last 3 months, etc.

Solution: Group nonterminals based on types

\[ f : \text{Duration} \rightarrow \text{Range} \]

\[ \text{Duration} \]

\[ \text{last} \]

\[ \text{Number} \]

\[ 3 \]

\[ \text{months} \]
Nonterminals become very sparse

Consider: last 7 days, last 3 months, etc.

Solution: Group nonterminals based on types

\[ f : \text{Duration} \rightarrow \text{Range} \]

What are these nonterminals, and how do they combine?
Grammar Of Time

- Range
- Sequence
- Duration
Grammar Of Time

Range

Sequence

Duration

Functions

Number

Nil (no temporal meaning)
Grammar Of Time

**Range**

A period between two dates (or times)
Grammar Of Time

Range

A period between two dates (or times)

*Today, June 5 2012, day before yesterday*
Range

A period between two dates (or times)

*Today, June 5 2012, day before yesterday*

Interval-based theory of time: instants are ranges

*Today* and *Reference* both ranges, but former has duration
Grammar Of Time

- Range
- Sequence

A sequence of Ranges (not necessarily at regular intervals)
Grammar Of Time

```
Range

Sequence

A sequence of Ranges (not necessarily at regular intervals)

June 5, last Sunday, third quarter
```
Grammar Of Time

Range

Sequence

A sequence of Ranges (not necessarily at regular intervals)

*June 5, last Sunday, third quarter*

Still stuck: which element are we referring to?
Grammar Of Time

Range

Sequence

A sequence of Ranges (not necessarily at regular intervals)

*June 5, last Sunday, third quarter*

Still stuck: which element are we referring to?

Answer: We’re referring to all of them! (Kind of...)
Today is 2012-06-05, what is last Sunday?
Grammar Of Time

Range

Sequence

Today is 2012-06-05, what is last Sunday?

June 3, 2012?
Today is 2012–06–05, what is last Sunday?

May 27, 2012?
June 3, 2012
Grammar Of Time

Today is 2012-06-05, what is last Sunday?

- May 20, 2012?
- May 27, 2012
- June 3, 2012
- June 10, 2012?
Grammar Of Time

**Range**

**Sequence**

Today is 2012-06-05, what is *last Sunday*?

- 0.04 May 20, 2012
- 0.24 May 27, 2012
- 0.43 June 3, 2012
- 0.17 June 10, 2012

Construct a distribution over possible groundings
Grammar Of Time

Range

Sequence

Today is 2012-06-05, what is last Sunday?

0.04 May 20, 2012
0.24 May 27, 2012
0.43 June 3, 2012
0.17 June 10, 2012

Construct a distribution over possible groundings

Appealing to model as a Gaussian
Grammar Of Time

Range

Sequence

Today is 2012-06-05, what is last Sunday?

0.04 May 20, 2012
0.24 May 27, 2012
0.43 June 3, 2012
0.17 June 10, 2012

Construct a distribution over possible groundings

Appealing to model as a Gaussian

Learn Gaussian parameters $\mu, \sigma$
Grammar Of Time

Range

Sequence

Duration

A period of time: day, 2 weeks, 10 years
Grammar Of Time

Range

Sequence

Duration

Functions

General sequence and interval operations
Grammar Of Time

Range

Sequence

Duration

Functions

General sequence and interval operations

Examples:

Shift a range/sequence by a duration \([3 \text{ days ago}]\)
Move the origin of a sequence \([\text{last Sunday}]\)
Take the \(n^{th}\) element of a sequence \([\text{second week of June}]\)

\ldots
Grammar Of Time

Range

Sequence

Duration

Functions

Number

A number, characterized by its ordinality and magnitude
Grammar Of Time

Range

Sequence

Duration

Functions

Number

Nil

A word without direct temporal meaning
Grammar Of Time

Range
Sequence
Duration
Functions
Number

Nil

A word without direct temporal meaning
Lexicalized: e.g., Nil-the, Nil-a

a week
the week
Grammar Of Time

Range
Sequence
Duration
Functions
Number
Nil

Combination Rules
Predefined combination rules
Type checking function application
Training Setup

Given \{ (x, y) \}
Training Setup

Given \{ ((Phrase, Reference), Time) \}
Training Setup

**Given** \{ ((Phrase, Reference), Time) \}

Not given latent parse
Not given lexical cues
Training Setup

**Given** \{ ( ( Phrase, Reference ), Time ) \}

- Not given latent parse
- Not given lexical cues

Therefore, in general, latent parse is ambiguous
Training Setup

Given \{ ((\text{Phrase}, \text{Reference}), \text{Time}) \}

Not given latent parse
Not given lexical cues

Therefore, in general, latent parse is ambiguous

\(( (w_1 \ w_2, 2012-06-05), 2012-06-12) \)
Training Setup

Given \{ ((Phrase, Reference), Time) \}

Not given latent parse
Not given lexical cues

Therefore, in general, latent parse is ambiguous

( ( w_1 w_2 , 2012-06-05 ) , 2012-06-12 )

e.g., \( w_1 = \text{next}, w_2 = \text{Tuesday} \)

moveRight1( TUE )

moveRight1( - )

moveRight1( - )

moveRight1( - )
Training Setup

Given \( \{( \text{Phrase}, \text{Reference} ), \text{Time} \} \)

- Not given latent parse
- Not given lexical cues

Therefore, in general, latent parse is ambiguous

\[
( ( w_1, w_2, 2012-06-05 ), 2012-06-12 )
\]

- moveRight( \( x \), WEEK )
- moveRight( \( x, - \) )

\( w_1 \) and \( w_2 \) examples:
- \( w_1 = \text{next}, w_2 = \text{Tuesday} \)
- \( w_1 = \text{next}, w_2 = \text{week} \)
Training Setup

Given \{ ((\textit{Phrase}, \textit{Reference}), \textit{Time}) \}

Not given latent parse
Not given lexical cues

Therefore, in general, latent parse is ambiguous

( (w_1 w_2, 2012-06-05), 2012-06-12 )

e.g., \( w_1 = \text{next}, w_2 = \text{Tuesday} \)
e.g., \( w_1 = \text{next}, w_2 = \text{week} \)
e.g., \( w_1 = \text{the}, w_2 = \text{Tuesday} \)
Training: TimEM

E1 Step: Get $k$-best parses for phrase
Training: TimEM

E1 Step: Get $k$-best parses for phrase

( ( next Tuesday, 2012-06-05 ), 2012-06-12 )
Training: TimEM

E1 Step: Get $k$-best parses for phrase

$$(\text{next Tuesday}, 2012-06-05), 2012-06-12)$$
Training: TimEM

E1 Step: Get $k$-best parses for phrase

$$((\text{next Tuesday}, 2012-06-05), 2012-06-12)$$
Training: TimEM

E1 Step: Get $k$-best parses for phrase
E2 Step: Filter and re-weight correct parses

\[
( ( \text{next Tuesday}, 2012-06-05 ), 2012-06-12 )
\]
Training: TimEM

E1 Step: Get $k$-best parses for phrase
E2 Step: Filter and re-weight correct parses

( (next Tuesday, 2012-06-05), 2012-06-12 )
Training: TimEM

E1 Step: Get $k$-best parses for phrase
E2 Step: Filter and re-weight correct parses

$$((\text{next Tuesday}, 2012-06-05), 2012-06-12)$$

- moveRight1(TUE)
- moveRight(–) TUE
- moveRight1(TUE)
- moveRight(x,–) WEEK
- moveLeft1(TUE)
- moveLeft(–) TUE
- moveLeft1(FRI)
- moveLeft(–) FRI
- takeLeft(WEEK)
- takeLeft(–) WEEK
- takeRight(MONTH)
- takeRight(–) MONTH
- moveRight(x,–) MONTH

Scores:

- 0.57
- 0.36
- 0.00
- 0.07
- 0.00
- 0.00
- 0.00
- 0.00
Training: TimEM

E1 Step: Get $k$-best parses for phrase
E2 Step: Filter and re-weight correct parses
M Step: Update expected sufficient statistics

(moveRight1(TUE))
(moveRight1(−)
next Tuesday)

(moveRight(x, WEEK))
movelnext Tuesday

(moveLeft1(TUE))
moveLeft1(−)
next Tuesday

(moveLeft1(FRI))
movelnext Tuesday

(takeLeft(WEEK))

(takeRight(MONTH))

(moveRight(x, MONTH))
Training: TimEM

E1 Step: Get $k$-best parses for phrase
E2 Step: Filter and re-weight correct parses
M Step: Update expected sufficient statistics
Training: TimEM

E1 Step: Get $\kappa$-best parses for phrase
E2 Step: Filter and re-weight correct parses
M Step: Update expected sufficient statistics
Training: TimEM

**E1 Step:** Get $k$-best parses for phrase

**E2 Step:** Filter and re-weight correct parses

**M Step:** Update expected sufficient statistics

$\theta_{\text{Lex}} \leftarrow \text{moveRight1(–) } \text{Nil } \text{WEEK } \text{TUE}$

$\theta_{\text{Grammar}} \leftarrow$

$\mu_{\text{sequence}}, \sigma_{\text{sequence}} \leftarrow \text{TUE } + 0, \text{TUE } + 1$
Intuition

Bootstrap from short examples
Intuition

*Bootstrap from short examples*

*week*, then *next week*, ...
Intuition

Bootstrap from short examples
week, then next week, ...

Smoothing

Dirichlet prior on grammar parameters $\theta$
Gaussian prior on $\mu$ given MLE $\sigma$
TimEM Discussion

Intuition

Bootstrap from short examples

week, then next week, ... 

Smoothing

Dirichlet prior on grammar parameters $\theta$

Gaussian prior on $\mu$ given MLE $\sigma$

Uniform initialization $\rightarrow$ deterministic
Dataset

TempEval2

Newswire annotated for temporal expressions
Dataset

**TempEval2**

Newswire annotated for temporal expressions

1052 training / 156 test expressions
Dataset

**TempEval2**

Newswire annotated for temporal expressions
1052 training / 156 test expressions

**Evaluation**

Most likely grounding (e.g., June 5 → 2012-06-05)
Dataset

TempEval2
Newswire annotated for temporal expressions
1052 training / 156 test expressions

Evaluation
Most likely grounding (e.g., June 5 → 2012-06-05)

Type: Accuracy over result’s temporal type

June 5, 2012 = June 12, 2012
Dataset

TempEval2
Newswire annotated for temporal expressions
1052 training / 156 test expressions

Evaluation
Most likely grounding (e.g., June 5 → 2012–06–05)

Type: Accuracy over result’s temporal type

| June 5, 2012 |  ≠ | June 12, 2012 |

Value: Accuracy over result’s value, if types match

| June 5, 2012 |  ≠ | June 12, 2012 |
Dataset

TempEval2

Newswire annotated for temporal expressions
1052 training / 156 test expressions

Evaluation

Most likely grounding (e.g., June 5 → 2012-06-05)

Type: Accuracy over result’s temporal type

June 5, 2012 = June 12, 2012

Value: Accuracy over result’s value, if types match

June 5, 2012 ≠ June 12, 2012

Constrained to guess on each example; no contextual cues
Results

Comparisons

**GUTime** (Mani and Wilson, 2000)

**SUTime** (Chang and Manning, 2012)

**HeidelTime** (Strötgen and Gertz, 2010)
## Results

### Comparisons

- **GUTime** (Mani and Wilson, 2000)
- **SUTime** (Chang and Manning, 2012)
- **HeidelTime** (Strötgen and Gertz, 2010)

### Test (all expressions; gold detection)

<table>
<thead>
<tr>
<th>System</th>
<th>Type</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>GUTime</td>
<td>0.80</td>
<td>0.42</td>
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Results

Comparisons

GUTime (Mani and Wilson, 2000)
SUTime (Chang and Manning, 2012)
HeidelTime (Strötgen and Gertz, 2010)

Test (all expressions; gold detection)

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Results

Comparisons

GUTime (Mani and Wilson, 2000)
SUTime (Chang and Manning, 2012)
HeidelTime (Strötgen and Gertz, 2010)

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<tr>
<td>HeidelTime</td>
<td>0.85</td>
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Results

Comparisons

GUTime (Mani and Wilson, 2000)
SUTime (Chang and Manning, 2012)
HeidelTime (Strötgen and Gertz, 2010)

Test (all expressions; gold detection)

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<th>System</th>
<th>Type</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>GUTime</td>
<td>0.80</td>
<td>0.42</td>
</tr>
<tr>
<td>SUTime</td>
<td>0.94</td>
<td>0.71</td>
</tr>
<tr>
<td>HeidelTime</td>
<td>0.85</td>
<td>0.71</td>
</tr>
<tr>
<td>ParsingTime</td>
<td>0.88</td>
<td>0.72</td>
</tr>
</tbody>
</table>
Conclusion

Probabilistic, compositional temporal parsing

Elegant compositional representation of time

EM-like algorithm for learning
Conclusion

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- Results competitive with state-of-the-art
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Takeaway points

Capture **syntactic** ambiguity: \textit{last Friday the 13^{th}}
Capture **pragmatic** ambiguity: \textit{last Sunday}
Conclusion

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Takeaway points

  Capture **syntactic** ambiguity: *last Friday the 13th*
  Capture **pragmatic** ambiguity: *last Sunday*
  **Robust** guess and confidence for any expression
Conclusion

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Takeaway points
Capture **syntactic** ambiguity: *last Friday the 13th*
Capture **pragmatic** ambiguity: *last Sunday*
Robust guess and confidence for any expression
Language/domain independent approach
Thank You!

(We’re out of time)