

## Newspaper Text

NEW YORK (AP) - Martha Stewart thanked viewers of her television shows and readers of her magazines and websites for their support on Monday after meeting with a probation officer following her conviction for lying about a stock sale.

She made the remarks as she was getting into the front passenger seat of a sport utility vehicle outside a lower Manhattan courthouse, where she met with a probation officer for about an hour. "I want to thank my readers, my viewers and the Internet users," Stewart said just before closing the door behind her.

The probation meeting is the first step toward sentencing on June 17.

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## Processing Temporal Relations: Why?

- Question-Answering:  
Did Stewart meet a probation officer before her sentence?
- Dialogue Systems:  
What flights to NY do you have in a week from today?
- Information Extraction  
John was killed yesterday
- Natural-Language Generation and Summarization
- Novelty detection

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## Temporal Relations in Discourse

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## Analysis

- In some texts, timeline is a backbone of discourse organization
- (Newspaper) texts are rife with time switches
- We can typically recreate a timeline of events
- Temporal information is reflected via tense, connectives, temporal markers

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## Reichenbach's Topology of Tense

Reichenbach (1947)

- Point of speech (S)
- Point of event (E)
- Point of reference (R)

John has climbed Everest. (EiR=S)

John is in the class. (E=R=S)

John will climb Everest (S<E=R)

John had climbed Everest (E<R<S)

John will have climbed Everest (S<E<R)

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## Temporal Processing: Knowledge Sources

(Lascarides&Asher, 1993)

- Tense and aspect  
Mike entered the room. He had drunk/was drinking the wine.
- Temporal Adverbials/Connectives  
A drunken man died in the central Philippines when he put a firecracker under his armpit.
- World Knowledge  
Mike kissed the girl he met at a party.

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## Today

- Time marker disambiguation
- Event ordering
  - Inter-sentential
  - Intra-sentential

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## Tense as Discourse Anaphora

(Webber, 1988)

John went into the florist shop.

He had promised Mary some flowers.

She said she wouldn't forget him if he forgot.

So he picked up three rose, two white ones, and one pink.

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## Resolving Temporal Expressions

(Mani&Wilson, 2001)

- Primary Goal: Disambiguation of speaker and reference time dependent time markers  
“now”, “today”, “next Tuesday”
- Secondary Goal: Construction of event chronologies

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## Algorithm for TIMEX tagging

- Identify TIMEX
- Resolve self-Contained
- Propagate annotations based on context
  - Track Reference Time based on Temporal Focus and Document creation date

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## Studies of Tense

(we will not cover today, but see the references)

- Linguistic analysis of tense:  
(Kamp&Reyle, 1993; Moens&Steedman, 1988)
- Annotation Schemes:  
(Setzer and Gaizauskas, 2001)

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## Annotation Scheme

ISO standard: CC:YY:MM:DD:HH:XX:SS

Time points are treated as primitives (Bennett&Partee, 1972)

- “Tuesday, November 2, 2002” → 20:00:11:02
- “From May 1999 to June 1999” is represented as two points
- “April is usually wet” is not marked as TIMEX

Only 25% of clauses have time marker

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## Assigning Time Values(2)

Rule-based approach for propagation of TIMEX:

- Positional offsets from reference time: “next month”, “this coming Thursday”
- Implicit offset based on verb tense: “The first shipment was loaded Thursday”
- Use of lexical markers: “after”, “until”

Accuracy: above 80%

## Ordering Events:Features

- Type of verb: reporting, stative, accomplishment
- Tense and Aspect in the current clause, and shifts from previous clauses
- Presence of anchor and TIMEX
- Syntactic features: type of conjunction, modifiers and propositions

## Assigning Time Values(1)

remove SEMI-TIMEX expressions, such as “today” in “USA TODAY”

- Method: Binary Classification
- Features:
  - POS info: word before, word after
  - Lexical info: presence of “said”, “will”, “year”, “most”
  - Temporal markers: presence of a year or a day
  - Context: whether appear in quotations

Accuracy: 79.8%, Baseline 66.5%

## Ordering Events:Method

$n$  -class classification

- Anchor Relations: at, before, after, undefined
- Reference Time moves: keep, revert, shift

## Unsupervised Approach

(Lapata&Lascarides, 2004)

Goal: Infer Sentence-internal Temporal Relations

Key Idea: Use connectives as predictors of relations

Leonard Shane, 65, held the post of president before William Shane, 37, was elected to it last year.

The results were announced after the market closed.

Leaving the party, John walked home.

## Model

Assuming conditional independence of subordinate from main clause:

$$\operatorname{argmax}_{t_j} P(t_j) P(S_M | t_j) P(S_S | t_j)$$

Assuming feature independence:

$$\operatorname{argmax}_{t_j} P(t_j) \prod_i P(a_{(M,i)} | t_j) P(a_{(S,i)} | t_j)$$

## Results

Tested on 2069 clauses

	ANCHORS	REF MOVES
MAJORITY	76.9%(AT)	65.75% (KEEP)
ML	80.2%	71.8%

## Model

$$\begin{aligned} t &= \operatorname{argmax}_{t_j} P(S_M, t_j, S_S) = \\ &= \operatorname{argmax}_{t_j} P(S_M) P(t_j | S_M) P(S_S | S_M, t_j) = \\ &= \operatorname{argmax}_{t_j} P(t_j | S_M) P(S_S | S_M, t_j) = \\ &= \operatorname{argmax}_{t_j} P(t_j) P(S_M | t_j) P(S_S | S_M, t_j) \end{aligned}$$

## Model Features:Lexico-Semantic

- Verb Identity
- Verb Class (15 classes of WordNet, 200 Levin)
- Noun Identity
- Noun Class (25 WordNET classes)
- Adjective

## Parameter Estimation

- Decision tree on one-feature classifiers
- Standard feature selection

## Model Features:Temporal

FINITE = {past, present}  
NON-FINITE = {infinitive, ing-form, en-form}  
MODALITY = {NIL, future, ability, possibility, obligation  
}  
ASPECT = {imperfective, perfective, progressive}  
VOICE = {active, passive } NEGATION = {affirmative,  
negative }

## Model Features:Others

- Syntactic Feature (complexity)
- Argument Feature (verb tendency to take objects, PPs, ...)
- Relative Position of S and M

## Results

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83,810 (80% training, 10% development/testing)

- 64% accuracy (note that some connectives are interchangeable)
- Best features: verb, verb classes, syntactic structure, position
- No impact: nouns, adjectives, temporal