Natural Language Processing
Semantic Role Labeling

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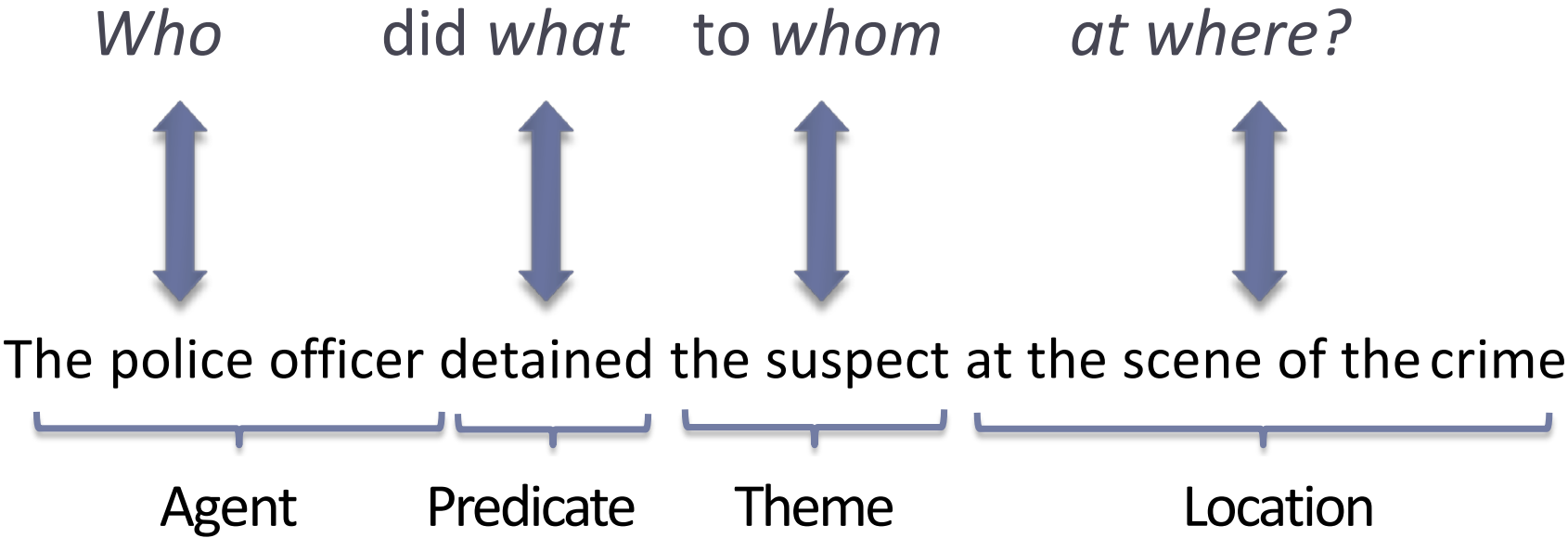
Syntactic Variation

- Last week, Min broke the window with a hammer.
- The window was broken with a hammer by Min last week
- With a hammer, Min broke the window last week
- Last week, the window was broken by Min with a hammer
- Min broke the window
- The window broke
- The window was broken with a hammer

Semantic Role Labeling

- Determining
  - who
  - did what
  - to whom
  - when
  - where
  - why
  - how
- Uses
  - Question answering
  - Machine translation
  - Text summarization

Semantic Role Labeling



A Shallow Semantic Representation: Semantic Roles

Predicates (bought, sold, purchase) represent an **event**
semantic roles express the abstract role that arguments of a predicate can take in the event

Semantic Role Labeling (SRL)

- For each clause, determine the semantic role played by each noun phrase that is an argument to the verb.

  agent patient source destination instrument

  - John drove Mary from Austin to Dallas in his Toyota Prius.
  - The hammer broke the window.
- "shallow semantic parsing"

Semantic Roles

- One of the oldest linguistic models
  - Indian grammarian Panini between the 7th and 4th centuries BCE
- Modern formulation from Fillmore (1966,1968), Gruber (1965)
- A variety of semantic role labels have been proposed.

Grammatical Cases

- Grammar case: The structure of sentences is analyzed in terms of semantic case relationships.
- Associated with each verb sense is a set of cases.
  - obligatory and optional

Case Theory

- **Agent**: Actor /initiator of some action, capable of acting with volition.
  - **The musician** performed a new piece
- **Patient**: The entity undergoing the effect of some action, often undergoing some change of state.
  - Samantha hurt **her hand**
  - Sue mowed the **lawn**
- **Theme:** The entity which is moved by an action, or whose location is described.
  - Fred threw **the rock**
- **Beneficiary**: Entity for whom action is performed
  - The mother bought ice cream **for the children**
  - Mary studied hard **for her mother**

Case Theory

- **Experiencer:** the entity which is aware of the action or state described by the predicate but which is not in control of the action or state.
  - **Kim** saw the deer
  - **John** has a headache
- **Instrument**: Tool used in performing action
  - Min broke the window **with a hammer**
- **Source**: Origin of the affected entity
  - I got the book **from my friend**
- **Destination**: Destination of the affected entity
- **Force**: The non-volitional causer of the event
  - **The wind** blows debris from the mall into our yards.

Thematic grid, case frame

Example usages of "break"

John broke the window.

AGENT THEME

John broke the window with a rock.

AGENT THEME INSTRUMENT

The rock broke the window

INSTRUMENT THEME

The window broke.

THEME

The window was broken by John.

THEME AGENT

thematic grid, case frame

Break:

AGENT, THEME, INSTRUMENT.

Some realizations:

1. AGENT/Subject, THEME/Object
2. AGENT/Subject, THEME/Object, INSTRUMENT/PPwith
3. INSTRUMENT/Subject,THEME/Object
4. THEME/Subject

Thematic-Role Grid (θ-grid)

- Lexicon specifies thematic roles associated with arguments of a verb
  - **put** V: <Agent, Theme, Location>

    Fred$_{\text{AGENT}}$ put the glass$_{\text{THEME}}$ on the table$_{\text{LOCATION}}$
- Verb subclasses share the same θ-grid:
  TRANSFER VERBS:
  - V: <Agent, Theme, Recipient>
    - give, lend, supply, pay, donate, contribute
  - V: <Recipient, Theme, Source>
    - receive, accept, borrow, buy, purchase, rent, hire

Problems with Thematic Roles

Hard to create standard set of roles or formally define them

Often roles need to be fragmented to be defined.

Levin and Rappaport Hovav (2015): two kinds of INSTRUMENTS

intermediary instruments that can appear as subjects

The cook opened the jar with the new gadget.

The new gadget opened the jar.

enabling instruments that cannot

Shelly ate the sliced banana with a fork.

*The fork ate the sliced banana.

Alternatives to thematic roles

1. **Fewer roles**: generalized semantic roles, defined as prototypes (Dowty 1991)
   Proto-agent
   Proto-patient
   PropBank
2. **More roles**: Define roles specific to a group of predicates
   FrameNet

- Roles in PropBank are specific to a verb
- Role in FrameNet are specific to a **frame: a** background knowledge structure that defines a set of frame-specific semantic roles, called **frame elements**,
  - includes a set of predicates that use these roles
  - each word evokes a frame and profiles some aspect of the frame

Framenet

- Baker et al. 1998, Fillmore et al. 2003, Fillmore and Baker 2009, Ruppenhofer et al. 2006
- A semantic frame can be thought of as a conceptual structure describing an event, relation, or object and the participants in it.
  - Examples: Being_born, locative_relation
- **Frame elements:** Each frame has a number of core and non-core FEs or semantic roles.
- Core FEs are essential to the meaning of the frame while non-core FEs are generally descriptive (such as time, place, manner, etc.)

Frame Semantics

- Sell (v) – to exchange an item for money or its equivalent
- Definition of a word is useless without knowledge relating to that word:
  - Entities involved - buyer, seller, item, money
  - Relationships between those entities:
    - Buyer gives money to seller
    - Seller gives item to buyer
    - Buyer believes value of item >= monetary amount
    - Seller believes value of item <= monetary amount

Framenet

- Set of *semantic frames*
- Composed of *frame elements (FEs)* – roles within the frame
- Words that evoke this frame are called *lexical units(LUs)* – represent a sense of a given word
- Frame: Commerce_sell
- FEs: buyer, seller, item, money, place, reason…
- LUs: auction.v, retail.v, vend.v…

- FrameNet: contains over 1,200 semantic frames, 13,000 lexical units (a pairing of a word with a meaning)

Capturing descriptions of the same event by different nouns/verbs

[$_{\text{Arg1}}$ The price of bananas] increased [$_{\text{Arg2}}$ 5%].

[$_{\text{Arg1}}$ The price of bananas] rose [$_{\text{Arg2}}$ 5%].

There has been a [$_{\text{Arg2}}$ 5%] rise [$_{\text{Arg1}}$ in the price of bananas].

The “Change position on a scale” Frame

This frame consists of words that indicate the change of an ITEM’s position on a scale (the ATTRIBUTE) from a starting point (INITIAL VALUE) to an end point (FINAL VALUE)

)) [ITEM Oil] *rose* [ATTRIBUTE in price] [DIFFERENCE by 2%].

l) [ITEM It] has *increased* [FINAL_STATE to having them 1 day a month].

2) [ITEM Microsoft shares] *fell* [FINAL_VALUE to 7 5/8].

3) [ITEM Colon cancer incidence] *fell* [DIFFERENCE by 50%] [GROUP among men].

4) a steady *increase* [INITIAL_VALUE from 9.5] [FINAL_VALUE to 14.3] [ITEM in dividends]

5) a [DIFFERENCE 5%] [ITEM dividend] *increase*...

The “Change position on a scale” Frame

VERBS:	dwindle	move	soar	escalation	shift
advance	edge	mushroom	swell	explosion	tumble
climb	explode	plummet	swing	fall	
decline	fall	reach	triple	fluctuation	**ADVERBS:**
decrease	fluctuate	rise	tumble	gain	increasingly
diminish	gain	rocket		growth	
dip	grow	shift	**NOUNS:**	hike	
double	increase	skyrocket	decline	increase	
drop	jump	slide	decrease	rise	

Frame-Frame Relations

- Inheritance – IS-A relation
  - Child frame is subtype of parent frame
  - Each frame element in parent has corresponding frame element in child
  - Revenge inherits from Rewards_and_punishments
- Using – child frame presupposes parent frame as background
  - Speed presupposes Motion
  - No one-to-one correspondence between FEs
- Subframe – child frame is subevent of complex event represented by parent
  - Criminal_process -> Arrest, Arraignment, Trial, Sentencing
- Perspective-on – one frame provides some perspective on (perspectivizes) another frame
  - Commerce_goods_transfer provides perspective on Commerce_sell

Schematic of Frame Semantics

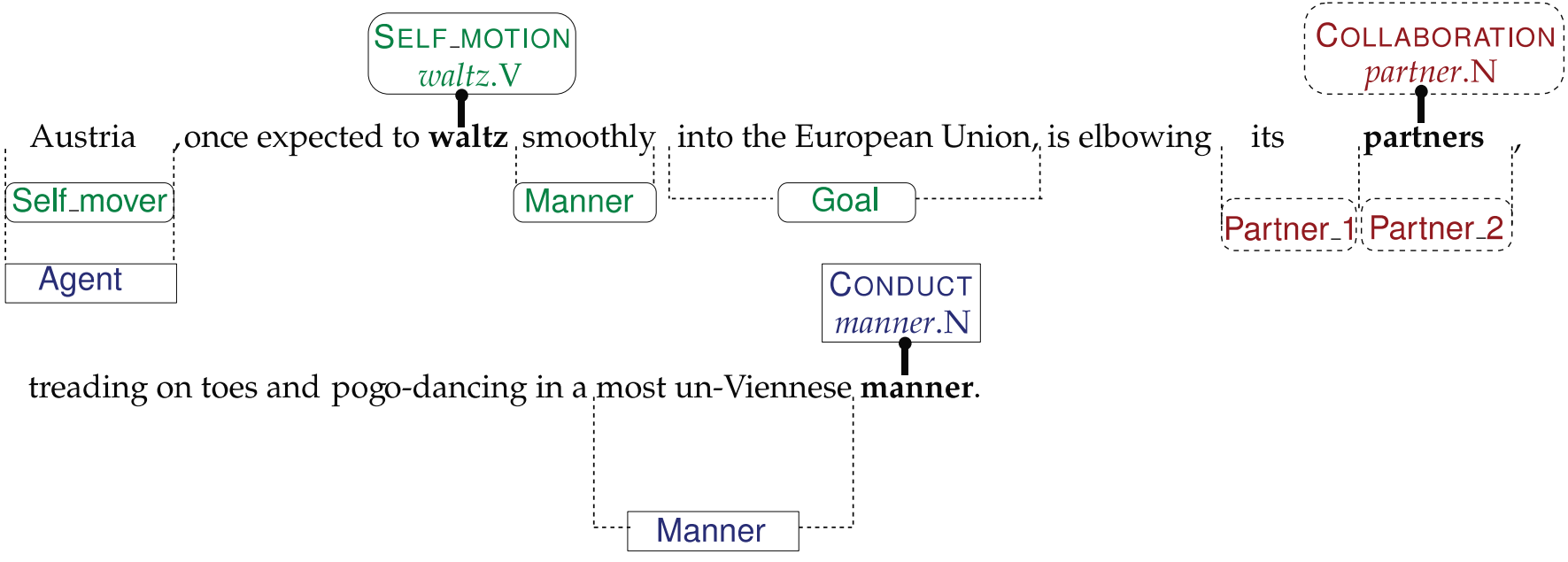


Figure from Das et al (2014)