Predicate Logic and Proposition Bank

LING 7430
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Comparing Logics

Ontology (ont = 'to be'; logica = 'word'): kinds of things one can talk about in the language

Examples:

• Propositional Logic	Facts
• Predicate Logic	Objects, Relationships among Objects
• Temporal Logics	Time Points or Intervals

Modeling Our World

- Propositions.
  - Alan-in-R225, Sam-in-R216, Jim-in….
  - R225-part of-Pender, R216-part of-Moore
- Limited.
  - Quickly gets explosive and cumbersome, can't express generalizations
  - Can't distinguish between objects and relations

Syntax of Predicate Logic

- Symbol set
  - **constants**
  - **Boolean connectives**
  - variables
  - functions
  - predicates (aka relations)
  - quantifiers
- Terms: variables, constants, functional expressions (can be arguments to predicates)
- Sentences:
  - atomic sentences (predicate expressions),
  - complex sentences (atomic sentences connected by Booleans),
  - quantified sentences

Examples of Terms: Constants, Variables and Functions

- Constants
  - Alan, Sam, R225, R216
- Variables
  - PersonX, PersonY, RoomS, RoomT
- Functions
  - father_of(PersonX)
  - product_of(Number1,Number2)

Examples of Predicates and Quantifiers

- Predicates
  - In(Octavian, Room4)
  - part of(Room4, UC)
  - fatherOf(PersonX,PersonY)
- Quantifiers
  - All dogs are mammals.
  - Some birds can't fly.
  - 3 birds can't fly.

Semantics of Predicate Logic

- A term is a reference to an object
  - constants
  - variables
  - functional expressions
- Sentences make claims about objects
  - Well-formed formulas, (wffs)

Semantics, part 2

- object constants refer to individuals
- there is a correspondence between
  - functions, which return values
  - predicates, which are true or false

Function: father_of(Mary) = Bill
Predicate: father_of(Mary, Bill)

Encoding Facts, (cont.)

pass(John, courses,40) **=>** graduate(John)

cavity(molar) **=>** x-ray_shadow(molar)

leak(pipe, kitchen) /\ full(pipe,water) **=>**
location(water, kitchen_floor)

KB Design Choices

Design choice: Implication of choice:

- red(block1) ⟶ ?????
- color(block1, red) ⟶ nice(red)
- val(color,block1,red) ⟶ property(color)

Extra credit opportunity: semantic predicate Representations of Flickr images

Combining Logical Symbols

- Terms: logical expressions referring to objects
  - sq_root(9), sq_root(n),
- Atomic Sentences:
  - loves(John,Mary), brother_of(John,Ted)
- Complex Sentences:
  - loves(John,Mary) ^ brother_of(John,Ted) ⇒ teases(Ted, John)

Quantifiers

- Universal Quantification

  All cats are mammals.

$$\forall x, Cat(x) \Rightarrow Mammal(x)$$

– For all x, such that x is a cat, x is a mammal

$$Cat(Garfield) \Rightarrow Mammal(Garfield)$$

Quantifiers

- Existential Quantifiers

A cat has an owner named John.
OR
There exists an entity such that that entity is a cat and has an owner named John.

$$\exists x, Owner(x, John), Cat(x)$$
$$Owner(Garfield, John), Cat(Garfield)$$
$$Owner(Rueben, John), Cat(Rueben)$$

Nested Quantifiers

$$\forall x, \exists y,\ Cat(x) \Rightarrow Owner(x, y)$$
$$Cat(Garfield) \Rightarrow Owner(Garfield, John)$$
$$Cat(Rueben) \Rightarrow Owner(Rueben, John)$$
$$\forall x, \forall y,\ owner(x, y) \Rightarrow loves(x, y)$$
$$owner(Rueben, John) \Rightarrow loves(Rueben, John)$$
$$owner(Garfield, John) \Rightarrow loves(Garfield, John)$$

Unique variable names!

First–Order Logic Examples

∀person ItIsRaining() → IsWet(person)

- Objects: *john, chair23, mother-Of(john)*
- Relations: *isWet(john)*, *isSittingOn(john,chair23)*
- Complex sentences:
  - Implications: *person(john) → likes(john, chocolate)*
  - Quantifiers and variables:
    (∀person)likes(person,chocolate)
    (∃person)¬eat(person,chocolate)

More First-Order Logic Examples

John loves Mary.

All crows are black.

Dolphins are mammals that live in the water.

Mary likes the color of one of John's ties

The Power of Expressivity

- Indirect knowledge:
  Tall(MotherOf(john))
- Counterfactuals: ¬*Tall(john)*
- Partial knowledge (disjunction):
  IsSisterOf(b,a) ∨ *IsSisterOf(c,a)*
- Partial knowledge (indefiniteness):
  ∃*xIsSisterOf(x,a)*

Wraps up Chap 17

- Problem Set 5
  - 17.2, 17.3, 17.4, 17.5
  - Won't be graded. Key will be posted on d2l
- Can our NLP systems produce FOL?

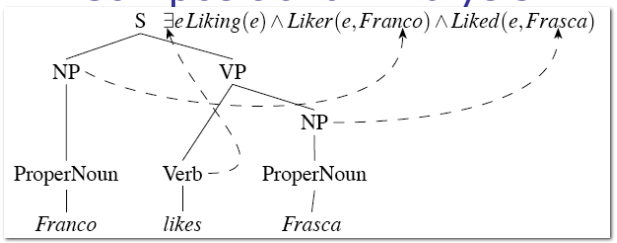
Chap 18 Computational Semantics

- Example

Franco likes Frasca.

$$\exists e Liking(e) \wedge Liker(e, Franco) \wedge Liked(e, Frasca)$$

Compositional Analysis



So, we need the ability to allow the verb to provide a template-like structure with slots to be filled in. And we need to specify where the slot fillers come from.

Augmented Rules

- We'll accomplish this by attaching semantic formation rules to our syntactic CFG rules
- Abstractly

$$A \rightarrow \alpha_1 \ldots \alpha_n \quad \{f(\alpha_1.sem, \ldots \alpha_n.sem)\}$$

- This should be read as the semantics we attach to A can be computed from some function applied to the semantics of A's parts.

Example

- Easy parts…
  - NP -> PropNoun
  - PropNoun -> Frasca
  - PropNoun -> Franco
- Attachments
  {PropNoun.sem}
  {Frasca}
  {Franco}

Example

- S -> NP VP
- VP -> Verb NP
- Verb -> *likes*
- {VP.sem(NP.sem)}
- {Verb.sem(NP.sem)
- ???

$$\lambda x \lambda y \exists e Liking(e) \wedge Liker(e, y) \wedge Liked(e, x)$$

Lambda Forms

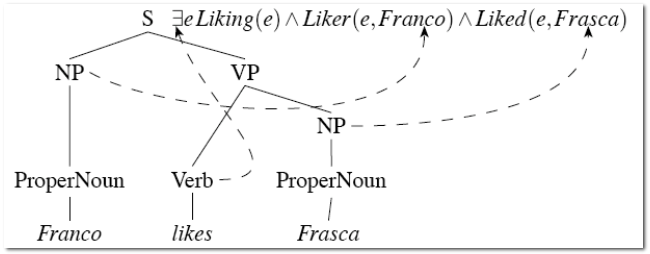
- A simple addition to FOL
  - Take a FOL sentence with variables in it that are to be bound.
  - Allow those variables to be bound by treating the lambda form as a function with formal arguments

$$\lambda x P(x)$$

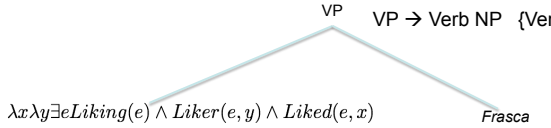
$$\lambda x P(x)(Sally)$$

$$P(Sally)$$

Compositional Semantics by Lambda Application



Lambda Applications and Reductions

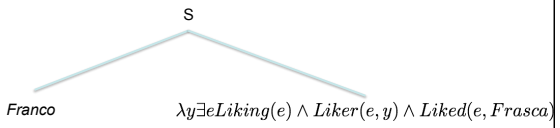


VP → Verb NP {Verb.sem(NP.Sem)

$$\lambda x \lambda y \exists eLiking(e) \wedge Liker(e, y) \wedge Liked(e, x)(Frasca)$$

$$\lambda y \exists eLiking(e) \wedge Liker(e, y) \wedge Liked(e, Frasca)$$

Lambda Applications and Reductions



$$\lambda y \exists eLiking(e) \wedge Liker(e, y) \wedge Liked(e, Frasca)(Franco)$$

$$\exists eLiking(e) \wedge Liker(e, Franco) \wedge Liked(e, Frasca)$$

S → NP VP {VP.sem(NP.sem) }

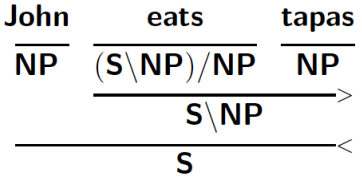
Complications

- You really ought to be suspicious that all those examples involve proper nouns that map to constants in the representation.
- That's the simplest possible case. Making it work for harder cases is more involved...
  - Mismatches between the syntax and semantics
    - Complex NPs with quantifiers

Complex NPs

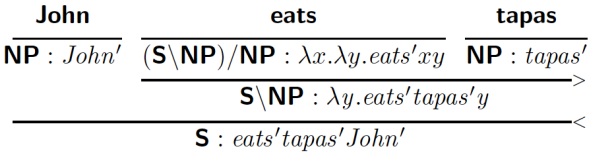
- Things get quite a bit more complicated when we start looking at more complicated NPs
  - Such as...
    - *A menu*
    - *Every restaurant*
    - *Not every waiter*
    - *Most restaurants*
    - *All the morning non-stop flights to Houston*
    - *Black cats and dogs*

A (C)CG derivation



CCG: semantics

- Every syntactic category and rule has a semantic interpretation
- Semantic interpretations are functions of the **same arity** as the syntactic category
- Semantics often written as **λ-expressions**

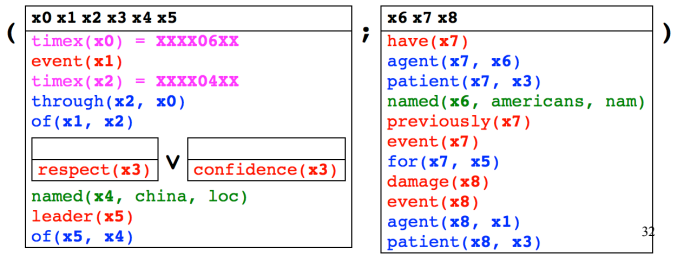


Boxer: from CCG to DRT

http://svn.ask.it.usyd.edu.au/trac/candc/wiki/Demo

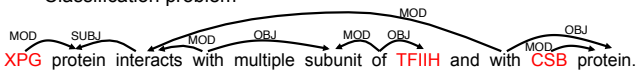
Translates CCG derivations (output of C&C parser) to Discourse Representation Theory

The events of April through June damaged the respect and confidence which most Americans previously had for the leaders of China .



Relation extraction

- Extracting relations expressed in texts
  - Protein-protein interactions
  - Gene-disease associations
  - Network of biological reactions (BioNLP'09 shared task)
- Train a machine learning classifier using parser output as features
  - Classification problem



<XPG, CSB> } positive
<XPG, TFIIH> }
<TFIIH, CSB> } negative

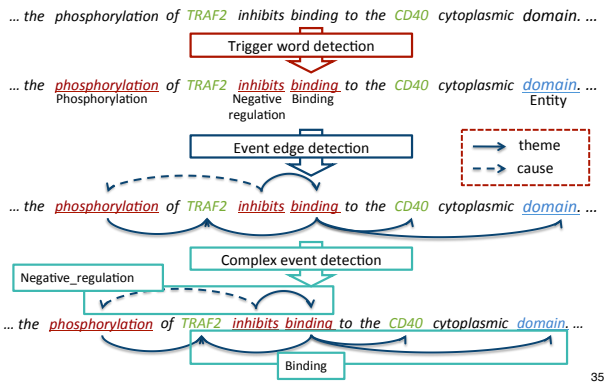
BioNLP'09 shared task

- Finding biological events from abstracts
  - Protein annotations are given

… In this study we hypothesized that the phosphorylation of TRAF2 inhibits binding to the CD40 cytoplasmic domain. …

negative_regulation
CAUSE:
phosphorylation
THEME: *TRAF2*
THEME:
binding
THEME: *TRAF2*
THEME2: *CD40*
SITE2: *cytoplasmic domain*

Event extraction system



Example

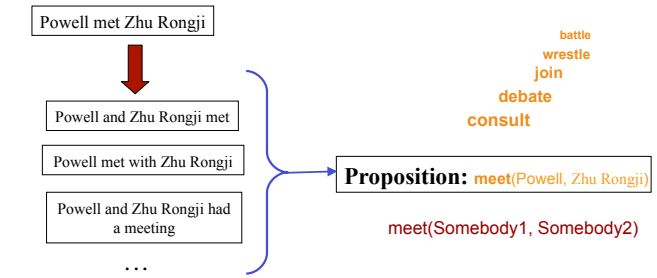
- S -> NP VP
- VP -> Verb NP
- Verb -> *likes*

- {VP.sem(NP.sem)}
- {Verb.sem(NP.sem)
- ???

$$\lambda x \lambda y \exists e Liking(e) \wedge Liker(e, y) \wedge Liked(e, x)$$

Where do these come from?

Proposition Bank:
From Sentences to Propositions (Predicates!)



When Powell met Zhu Rongji on Thursday they discussed the return of the spy plane.

meet(Powell, Zhu) discuss([Powell, Zhu], return(X, plane))

Capturing semantic roles*

SUBJ

• Richard broke [*PATIENT* the laser pointer.]

SUBJ

• [*PATIENT* The windows] were broken by the hurricane.

SUBJ

• [*PATIENT* The vase] broke into pieces when it toppled over.

Capturing semantic roles*

• Richard broke [ARG1 the laser pointer.]

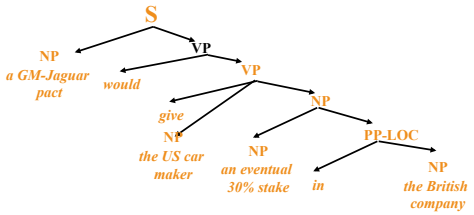
• [ARG1 The windows] were broken by the hurricane.

• [ARG1 The vase] broke into pieces when it toppled over.

*See also Framenet, http://www.icsi.berkeley.edu/~framenet/

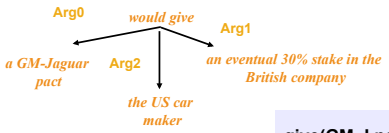
A TreeBanked phrase

A GM-Jaguar pact would give the U.S. car maker an eventual 30% stake in the British company.



The same phrase, PropBanked

A GM-Jaguar pact would give the U.S. car maker an eventual 30% stake in the British company.



give(GM-J pact, US car maker, 30% stake)

Frames File example: *give*

Roles:

Arg0: giver
Arg1: thing given
Arg2: entity given to

Example: double object

The executives gave the chefs a standing ovation.

Arg0:	*The executives*
REL:	*gave*
Arg2:	*the chefs*
Arg1:	*a standing ovation*

Annotation procedure

- PTB II – Extract all sentences of a verb
- Create Frame File for that verb *Paul Kingsbury*
  - (3100+ lemmas, 4700 framesets,120K predicates)
- First pass: Automatic tagging *Joseph Rosenzweig*
- Second pass: Double blind hand correction
  - Inter-annotator agreement 84%
- Third pass: *Solomonization* (adjudication)
  - *Olga Babko-Malaya*

Trends in Argument Numbering

- Arg0 = proto-typical agent (*Dowty*)
- Arg1 = proto-typical patient
- Arg2 = indirect object / benefactive / instrument / attribute / end state
- Arg3 = start point / benefactive / instrument / attribute
- Arg4 = end point

Additional tags (arguments or adjuncts?)

- Variety of ArgM's (Arg#>4):
  - TMP - when?
  - LOC - where at?
  - DIR - where to?
  - MNR - how?
  - PRP -why?
  - REC - himself, themselves, each other
  - PRD -this argument refers to or modifies another
  - ADV –others

Inflection, etc.

- Verbs also marked for tense/aspect
  - Passive/Active
  - Perfect/Progressive
  - Third singular (*is has does was*)
  - Present/Past/Future
  - Infinitives/Participles/Gerunds/Finites
- Modals and negations marked as ArgMs

Automatic Labelling of Semantic Relations

- Given a constituent to be labelled
- Stochastic Model
- Features:
  - Predicate, *(verb)*
  - Phrase Type, *(NP or S-BAR)*
  - Parse Tree Path
  - Position *(Before/after predicate)*
  - Voice *(active/passive)*
  - Head Word of constituent

Gildea & Jurafsky, CL02, Gildea & Palmer, ACL02

Additional Automatic Role Labelers

- Performance improved from 82.8% to 88% Colorado
  - (Gold Standard parses, < 10 instances)
  - Same features plus
    - Named Entity tags
    - Head word POS
    - For unseen verbs – backoff to automatic verb clusters
  - SVM's
    - Role or not role
    - For each likely role, for each Arg#, Arg# or not
    - No overlapping role labels allowed

Pradhan, et. al., ICDM03, Sardeneau, et. al, ACL03, Chen & Rambow, EMNLP03, Gildea & Hockemaier, EMNLP03

Additional Automatic Role Labelers

- Performance improved from 82.8% to 88% Colorado
- Penn results, original features, more labels, 88%, 93%
  - (Gold Standard parses, < 10 instances)
  - Same features plus
    - Named Entity tags
    - Head word POS
    - For unseen verbs – backoff to automatic verb clusters
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Word Senses in PropBank

- Orders to ignore word sense not feasible for 700+ verbs
  - *Mary left the room*
  - *Mary left her daughter-in-law her pearls in her will*

Frameset **leave.01** "move away from":
Arg0: entity leaving
Arg1: place left

Frameset **leave.02** "give":
Arg0: giver
Arg1: thing given
Arg2: beneficiary

How do these relate to traditional word senses in VerbNet and WordNet?

Frames: Multiple Framesets

- Out of the 787 most frequent verbs:
  - 1 Frameset – 521
  - 2 Frameset – 169
  - 3+ Frameset - 97 (includes light verbs)
  - 94% ITA

- Framesets are not necessarily consistent between different senses of the same verb

- Framesets are consistent between different verbs that share similar argument structures, *(like FrameNet)*

A Chinese Treebank Sentence

国会/Congress 最近/recently 通过/pass 了/ASP 银行法/banking law
"The Congress passed the banking law recently."

```
(IP (NP-SBJ  (NN 国会/Congress))
    (VP (ADVP (ADV 最近/recently))
        (VP (VV 通过/pass)
            (AS 了/ASP)
            (NP-OBJ (NN 银行法/banking law)))))
```

The Same Sentence, PropBanked

(IP (NP-SBJ arg0 (NN 国会))
(VP argM (ADVP (ADV 最近))
(VP f2 (VV 通过)
(AS 了)
arg1 (NP-OBJ (NN 银行法)))))

国会 最近 银行法 (law)
(congress)

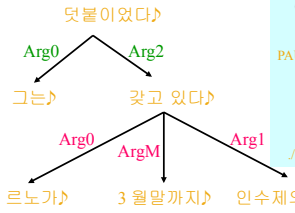
A Korean Treebank Sentence

그는 르노가 3 월말까지 인수제의 시한을 갖고 있다고 덧붙였다.♪

He added that Renault has a deadline until the end of March for a merger proposal.

(S (NP-SBJ 그/NPN+은/PAU)
(VP (S-COMP (NP-SBJ 르노/NPR+이/PCA)
(VP (VP (NP-ADV 3/NNU
월/NNX+말/NNX+까지/PAU)
(VP (NP-OBJ 인수/NNC+제의/NNC
시한/NNC+을/PCA)
갖/VV+고/ECS))
있/VX+다/EFN+고/PAD)
덧붙이/VV+었/EPF+다/EFN)
./SFN)♪

The same sentence, PropBanked



(S Arg0 (NP-SBJ 그/NPN+은/PAU)
(VP Arg2 (S-COMP (Arg0 NP-SBJ 르노/NPR+이/PCA)
(VP (VP (ArgM NP-ADV 3/NNU
월/NNX+말/NNX+까지/PAU)
(VP (Arg1 NP-OBJ 인수/NNC+제의/NNC
시한/NNC+을/PCA)
갖/VV+고/ECS))
있/VX+다/EFN+고/PAD)
덧붙이/VV+었/EPF+다/EFN)
./SFN)♪

덧붙이다 (그는, 르노가 3 월말까지 인수제의 시한을 갖고 있다)♪
(add) (he) (Renaut has a deadline until the end of March for a merger proposal)
갖다 (르노가, 3 월말까지, 인수제의 시한을)♪
(has) (Renaut) (until the end of March) (a deadline for a merger proposal)

Extensions

- Applied to Arabic, Hindi, Urdu
- Semi-supervised projections to French, Italian
- Extended to include eventive nouns, adjectives, light verb constructions, etc.
- Provides the basis for Abstract Meaning Representations