Case Grammar
Semantic Role Labeling

Slides from Prof. Nancy McCracken

Semantics of events in sentences

- In a sentence, a verb and its semantic roles form a proposition; the verb can be called the predicate and the roles are known as arguments.

When Disney offered to pay Mr. Steinberg a premium for his shares, the New York investor didn't demand the company also pay a premium to other shareholders.

Example semantic roles for the verb "pay" (using verb-specific roles)

When [$_{payer}$ Disney] offered to [$_{V}$ pay] [$_{recipient}$ Mr. Steinberg] [$_{money}$ a premium] for [$_{commodity}$ his shares], the New York investor …

CASE Grammar

- **Fillmore, Charles (1968) *"The Case for Case."***
  - A response to Chomsky's disregard for any semantics
    - "A semantically justified syntactic theory"

- Given a sentence, it is possible to say much more than this NP is the subject and this NP is the object

- Chomsky's Transformational Grammar would reduce active & passive versions of the same deep structure, but doesn't go far enough to reveal why this is is possible semantically
  - *A crowbar could open that door easily.*
  - *That door could be opened easily with a crowbar.*

CASE Grammar

- Focuses on conceptual events
  - for each event or situation, there is a limited number of roles/cases which people or objects play in the situation
  - roles reflect ordinary human judgments about:
    - Who did the action?
    - Who / what was it done to?
    - What was it done with?
    - Where was it done?
    - What was the result?
    - When was it done?

Syntactic structure vs. semantic structure

- Syntactic similarities hide semantic dissimilarities
  - ***We*** *baked every Saturday morning.*
  - *The* ***pie*** *baked to a golden brown.*
  - *This* ***oven*** *bakes evenly.*
  - 3 subject NPs perform very different roles in regard to *bake*

- Syntactic dissimilarities hide semantic similarities
  - $\text{John}_{\text{agent}}$ broke the $\text{window}_{\text{theme}}$.
  - $\text{John}_{\text{agent}}$ broke the $\text{window}_{\text{theme}}$ with a $\text{rock}_{\textit{instrument}}$.
  - The $\text{rock}_{\textit{instrument}}$ broke the $\text{window}_{\text{theme}}$.
  - The $\text{window}_{\text{theme}}$ broke.
  - The $\text{window}_{\text{theme}}$ was broken by $\text{John}_{\text{agent}}$.

Cases (aka Thematic Roles or Theta Roles)

- Some of Fillmore's original set of roles still in use as general descriptors of roles
  - **Agentive (A)**
    - the instigator of the action, an animate being
      - ***John*** *opened the door.*
      - *The door was opened by* ***John****.*
  - **Instrumental (I)**
    - the thing used to perform the action, an inanimate object
      - *The* ***key*** *opened the door.*
      - *John opened the door with the* ***key****.*
  - **Locative (L)**
    - the location or spatial orientation of the state or action of the verb
      - *It's windy in* ***Chicago****.*
- Other original roles not typically used
  - **Dative (D), Neutral (N), Objective (O), Factitive (F)**

Verb-specific Roles

- Difficult to fit many verbs and roles into the general thematic roles
  - Many general sets are proposed; not uniform agreement
  - Generalized semantic roles now often called
    - Proto roles (Dowty, 1989): Proto-agent, proto-patient, etc.
    - Or theta roles

The theta grid for give		
Agent source DP	theme DP	goal PP
i	j	k

$[_S[_{NP}$ Susan$]_i$ gave $[_{NP}$ the food$]_j$ $[_{PP}$to Biff$]_k]$

Example from: https://en.wikipedia.org/wiki/Theta_role

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    - Or theta roles
- Verb-specific roles are proposed in systems
  - PropBank annotates the verbs of Penn Treebank
    - Extended with NomBank for nominalizations
  - FrameNet annotates the British National Corpus
    - Uses domains of semantically similar verbs called frames.

Propbank

- Propbank is a corpus with annotation of semantic roles, capturing the semantic role structure of each verb sense
  - By Martha Palmer and Mitch Marcus at U Penn
- Each verb sense has a frameset, listing its possible semantic roles
    - Argument notation uses numbers for the annotation
    - First sense of accept (accept.01)
      - Arg0: acceptor
      - Arg1: thing accepted
      - Arg2: accepted-from
      - Arg3: attribute
- The frameset roles are standard across all syntactic realizations in the corpus of that verb sense
  - Each verb has a frameset file describing the args as above
    - Example texts are also given

http://verbs.colorado.edu/propbank/framesets-english-aliases/accept.html

Roles consistent with VerbNet

- Propbank builds on VerbNet to assign more specific roles.
- VerbNet is one extension of Levin's verb classes, giving semantic roles from about 20 possible roles
  - Agent, Patient, Theme, Experiencer, etc.
  - Similar to the theta roles
- Each class consists of a number of synonymous verbs that have the same semantic and syntactic role structure in a frame
- Whenever possible, the Propbank argument numbering is made consistent for all verbs in a VerbNet class.
  - There is only 50% overlap between Propbank and VerbNet verbs.
- Download from VerbNet: XML format

Semantic Role Notation for Propbank

- The first two numbered arguments correspond, approximately, to the core case roles:
  - Arg0 – Prototypical Agent
  - Arg1 – Prototypical Patient or Theme
  - Remaining numbered args are verb specific case roles, Arg2 through Arg5
- Another large groups of roles are the adjunctive roles (which can be applied to any verb) and are annotated as ArgM with a suffix:
  - ArgM-LOC – location
  - ArgM-EXT – extent
  - ArgM-DIR – direction
  - ArgM-ADV – general purpose adverbial
  - ArgM-DIS – discourse connective
  - ArgM-MOD – modal verb

  ArgM-CAU - cause
  ArgM-TMP - time
  ArgM-PNC – purpose
  ArgM-MNR - manner
  ArgM- NEG – negation

Adjunctive and additional arguments

- Example of adjunctive arguments
  - Not all core arguments are required to be present
    - See Arg2 in this example.
  - Arguments can be phrases, clauses, even partial words.

When Disney offered to pay Mr. Steinberg a premium for his shares, the New York investor didn't demand the company also pay a premium to other shareholders.

Example of Propbank annotation (on demand):

[$_{\text{ArgM-TMP}}$ When Disney offered to pay Mr. Steinberg a premium for his shares], [$_{\text{Arg0}}$the New York investor] did [$_{\text{ArgM-NEG}}$ n't] [$_{\text{V}}$ demand] [$_{\text{Arg1}}$ the company also pay a premium to other shareholders].

Where for demand, Arg0 is "asker", Arg1 is "favor", Arg2 is "hearer"

Propbank Annotations

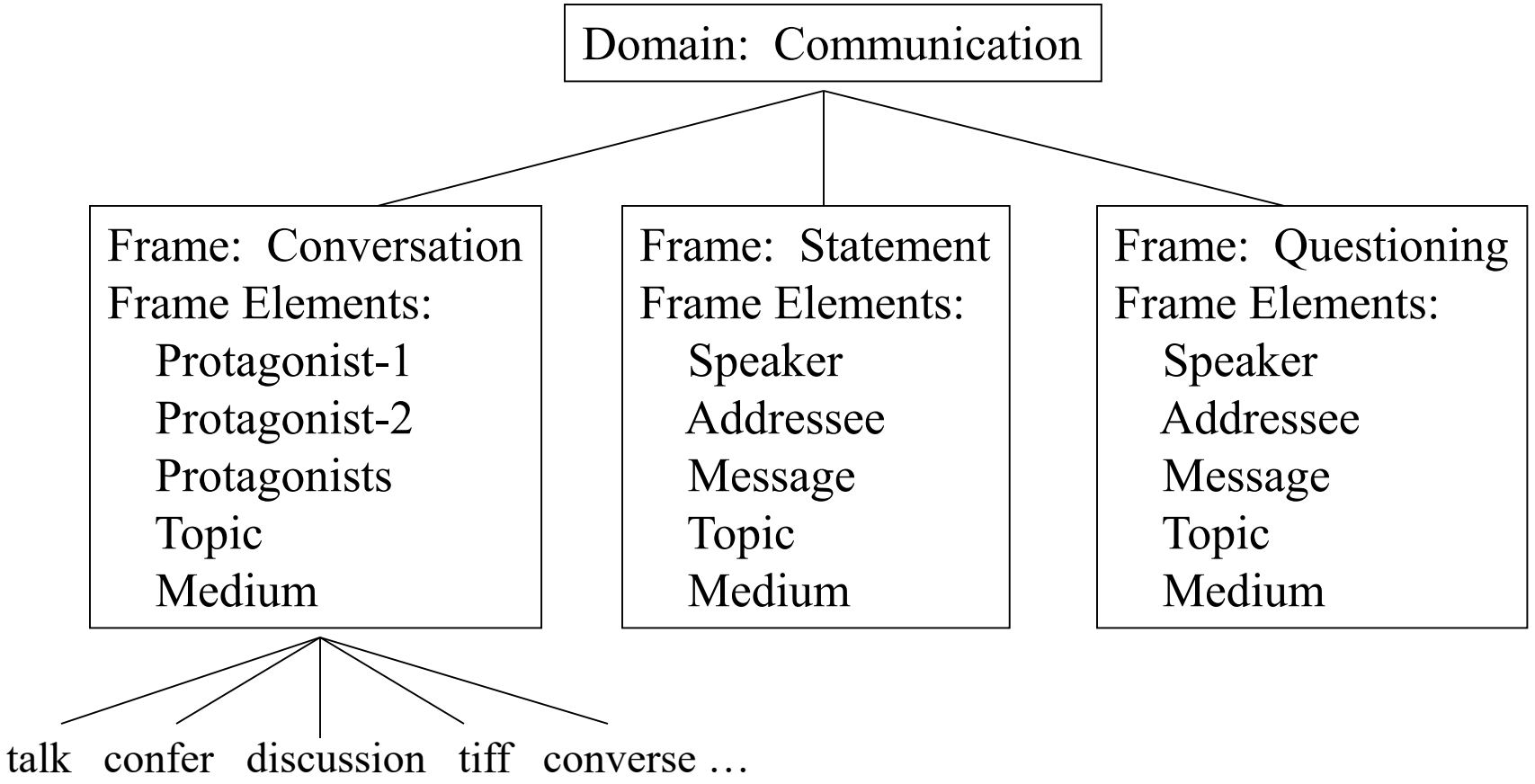
- Framesets were created by looking at sample sentences containing each verb sense.
  - ~ 4500 frames (in 3314 framesets for each verb)
- Corpus is primarily newswire text from Penn Treebank
  - Annotated the Wall Street Journal section, and, more recently, the "Brown" corpus
  - Verbs and semantic role annotations added to the parse trees
- Annotators are presented with roleset descriptions of a verb and the (gold) syntactic parses of a sentence in Treebank, and they annotate the roles of the verb.
  - Lexical sampling – annotated on a verb-by-verb basis.
  - ~40,000 sentences were annotated
- Interannotater agreement
  - Identifying argument and classifying role: 99%
    - kappa statistic of .91overall and .93 if ArgM's excluded

FrameNet

- Project at International Computer Science Institute with Charles Fillmore
  - http://framenet.icsi.berkeley.edu/
- Similar goal to document the syntactic realization of arguments of predicates in the English language
- Starts from semantic frames (e.g. Commerce) and defines frame elements (e.g. Buyer, Goods, Seller, Money)
- Annotates example sentences chosen to illustrate all possibilities
  - But recent release includes 132,968 sentences
  - British National Corpus

Example of FrameNet frames

- Semantic frames are related by topic domain



Comparison of FrameNet and Propbank

- FrameNet semantic roles are consistent for semantically related verbs (not just synonyms as in the VerbNet subset of PropBank)
- Commerce examples:

FrameNet annotation:

[$_{\text{Buyer}}$ Chuck] *bought* [$_{\text{Goods}}$ a car] [$_{\text{Seller}}$ from Jerry][$_{\text{Payment}}$ for $1000].
[$_{\text{Seller}}$ Jerry] *sold* [$_{\text{Goods}}$ a car] [$_{\text{Buyer}}$ to Chuck] [$_{\text{Payment}}$ for $1000].

Propbank annotation:

[$_{\text{Arg0}}$ Chuck] *bought* [$_{\text{Arg1}}$ a car] [$_{\text{Arg2}}$ from Jerry][$_{\text{Arg3}}$ for $1000].
[$_{\text{Arg0}}$ Jerry] *sold* [$_{\text{Arg1}}$ a car] [$_{\text{Arg2}}$ to Chuck] [$_{\text{Arg3}}$ for $1000].

Frame for buy:
Arg0: buyer
Arg1: thing bought
Arg2: seller
Arg3: price paid
Arg4: benefactive

Frame for sell:
Arg0: seller
Arg1: thing sold
Arg2: buyer
Arg3: price paid
Arg4: benefactive

Automatic SRL

- Define an algorithm that will process text and recognize roles for each verb
- Assume previous levels of Natural Language Processing (NLP) on text
  - Part-of-speech (POS) tagging,
  - Parse trees, dependency trees
- Machine Learning classification approaches are typical

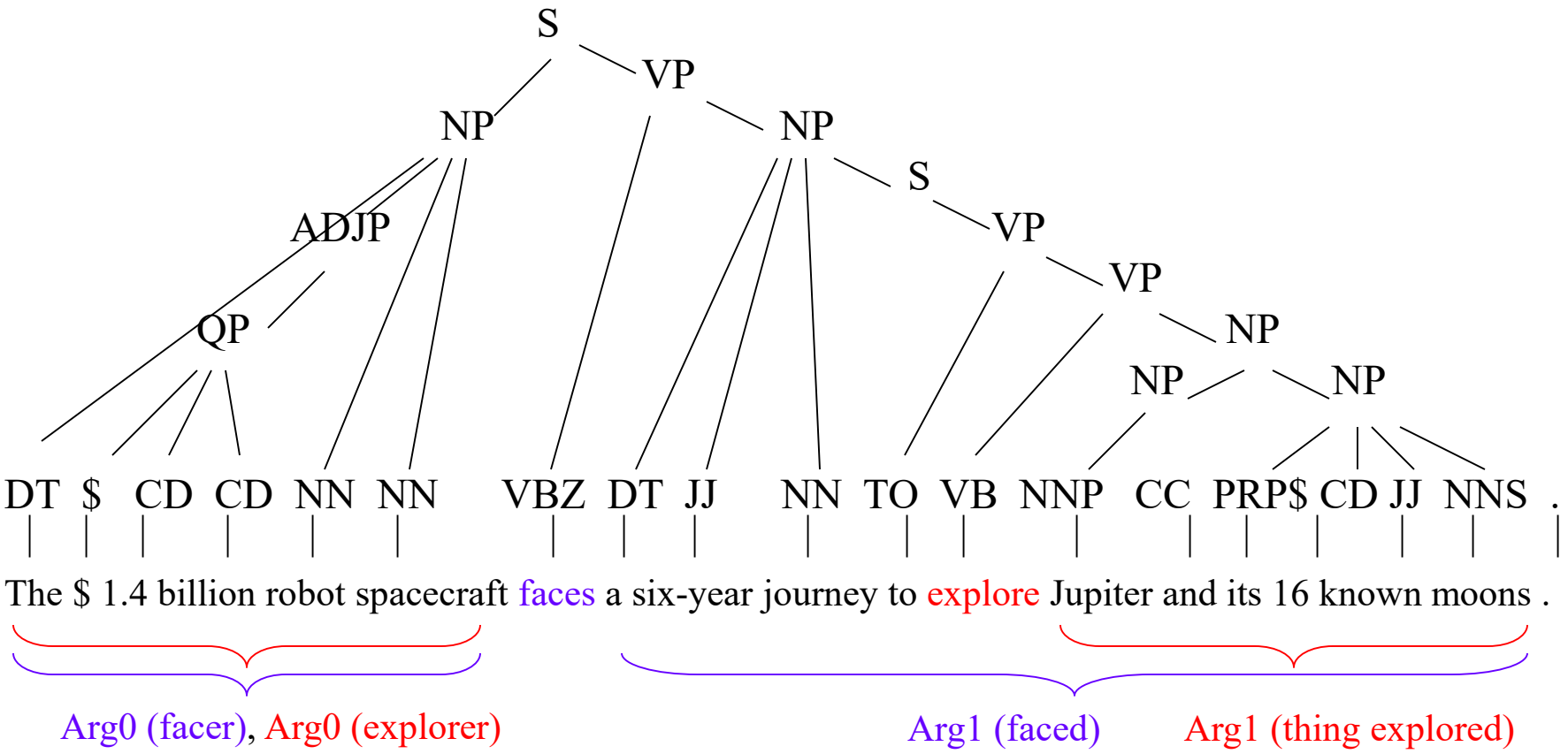
Machine Learning Approach

- Given a verb in a sentence, the problem is to find and label all arguments
- Reformulate as a classification task: For each constituent in the parse tree of the sentence, label it as to what argument, if any, it is for the verb

- For each constituent, define features of semantic roles
  - Each feature describes some aspect of a text phrase that can help determine its semantic role of a verb
    - Examples include what the verb is, POS tags, position in parse tree, etc.
- Machine Learning process:
  - Training:
    - Use annotated corpus of semantic roles with features and semantic role label
      - PropBank or FrameNet
    - ML training program uses examples to produce decision algorithm
  - Classification:
    - Run decision algorithm on text phrases and it will decide which, if any, semantic role it plays with respect to a verb

Parse Tree Constituents

- Each syntactic constituent is a candidate for labeling
- Define features from sentence processed into parse tree with Part-of-Speech tags on words



Typical Argument Features

- These features are defined for each constituent:
- PREDICATE: The predicate word from the training data.
  - "face" and "explore"
  - Usually stemmed or lemmatized
- PHRASE TYPE: The phrase label of the argument candidate.
  - Examples are NP, S, for phrases, or may be POS tag if a single word
- POSITION: Whether the argument candidate is before or after the predicate.
- VOICE: Whether the predicate is in active or passive voice.
  - Passive voice is recognized if a past participle verb is preceded by a form of the verb "be" within 3 words.
- SUBCATEGORY: The phrase labels of the children of the predicate's parent in the syntax tree.
  - subcat of "faces" is "VP -> VBZ NP"

Argument Features

- PATH: The syntactic path through the parse tree from the argument constituent to the predicate.
  - Arg0 for "faces": NP -> S -> VP -> VBZ
- HEAD WORD: The head word of the argument constituent
  - Main noun of NP (noun phrase)
  - Main preposition of PP (prepositional phrase)
- Many additional features
  - Head Word POS: The part of speech tag of the head word of the argument constituent.
  - Temporal Cue Words: Special words occurring in ArgM-TMP phrases.
  - Governing Category: The phrase label of the parent of the argument.
  - Grammatical Rule: The generalization of the subcategorization feature to show the phrase labels of the children of the node that is the lowest parent of all arguments of the predicate.

SRL problem constraints

- Results of the labeling classifier are probabilities for each label for that constituent
- Use these with constraints to assign a label
  - Two constituents cannot have the same argument label,
  - A constituent cannot have more than one label
  - If two constituents have (different) labels, they cannot have any overlap,
  - No argument can overlap the predicate.

Difficulties for classification

- For each verb in a sentence, the number of constituents in the parse tree are large compared to the number of semantic roles
  - Can be hundreds of constituents eligible to be labeled a role
  - Leads to the problem of too many “negative” examples
- What should the features be?
  - Words are typically the features for an NLP problem
  - Need more about the syntactic structure as well as other potential clues
  - Typical number of features can be up to 20,000, requiring a classification algorithm that is robust for large numbers of features

State-of-the-Art on Semantic Role Labeling

Marcheggiani, D., & Titov, I. (2017). Encoding sentences with graph convolutional networks for semantic role labeling. *arXiv preprint arXiv:1703.04826*.

A version of graph convolutional networks (GCNs), a recent class of neural networks operating on graphs, over syntactic dependency trees are used as sentence encoders, producing latent feature representations of words in a sentence. The stacked GCN and LSTM layers produce the best reported scored on the standard benchmark (CoNLL-2009) both for Chinese and English.