Towards an Automatic Classification of Transitive Verbs in English

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IMS

Motivation

- Linguistic issues of argument structure and transitivity
- NLP and Machine Learning techniques for investigation of linguistic issues
- Automatic acquisition of large-scale lexical resources for NLP applications

Outline

- Transitivity: Background
- Hypothesis & Objective
- Classification Approach
- Experiment
- Future Work
- References

Transitivity – Definition

Transitivity is traditionally understood as a global property of an entire clause, such that an activity is “carried-over” or “transferred” from an agent to a patient

[Hopper & Thompson, 1980]

Transitivity as a primitive notion (1)

Transitivity *continuum* as a composite of scores on 10 morphosyntactic and semantic parameters, e.g. aspect, volitionality, agentivity, affectedness of object etc.

[Hopper & Thompson, 1980]

Transitivity as a primitive notion (2)

- A verb's syntactic behavior can be predicted by its semantic meaning

  [Fillmore, 1970]

- Argument realization reflects event structure complexity

  [Rappaport-Hovav & Levin 1995, Levin 1999]

Transitivity as a primitive notion (3)

Two classes of transitive verbs:

- *Core Transitive Verbs* (CTV)

  e.g. *kill, destroy, open, cut , disappoint*

- *NonCore Transitive Verbs* (NCTV)

  e.g. *eat, hit, rub, sweep, detest*

[Levin, 1999]

Transitivity: 'Derived' Notion

- Transitivity is not a primitive notion that characterizes some verbal entry or not
- Argument realization is associated with structure [Hale & Keyser, 1993]
- Transitivity is a 'derived' notion for a set of structural relationships
  [Alexiadou 2003, Marantz 2003]

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Hypothesis

Syntactically relevant information about verbs is encoded in the lexicon in semantic event templates

- Transitive verbs can be partitioned into CTVs and NCTVs
- The contrast between CTVs and NCTVs is reflected in their argument expression

CTVs

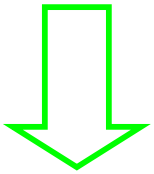
Semantic profile

Agent acts on and *necessarily* causes a change in the patient

CTVs

Complex event structure

[[x ACT <*MANNER*>] CAUSE [BECOME [y <*STATE*>]]]



Restricted argument expression

NCTVs

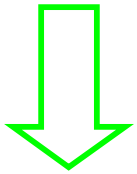
Semantic Profile

Agent acts and causes an effect on patient

NCTVs

Simple event structure

[x ACT <*MANNER*> y]



Varied argument expression

Argument Expression (Diagnostics)

Unlike CTVs, NCTVs allow:

- Unexpressed objects

  Mary scrubbed (the floor) this morning

- Resultative phrases

  She slammed herself inside the bedroom (reflexive resultative)

- Path phrases

  Mary pushed the car to the store

- *out*-prefixation

  I'm no slouch in the food department, but she consistently outordered and outate me

Objective

Classify transitive verbs on the basis of

- their morphosyntactic reflexes

- probability distribution of the reflexes

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Approach

- Use large data samples to automatically extract
  - Levin's morphosyntactic *diagnostics*
  - their *frequency* of occurrence

- *Classify* verbs automatically using standard classification algorithms

Extraction of Diagnostics (1)

Two types of diagnostics:

- Syntactic:
  - Resultative phrases
  - Path phrases
  - Frames
    - Unexpressed objects
    - …
- Morphological:
  - *out*-prefixation

Extraction of Diagnostics (2)

Data

- Annotated Text Corpora
  - BNC (~100 million words)
  - Tipster (~405 million words)
  - WSJ (~43 million words)
- World Wide Web (WWW)

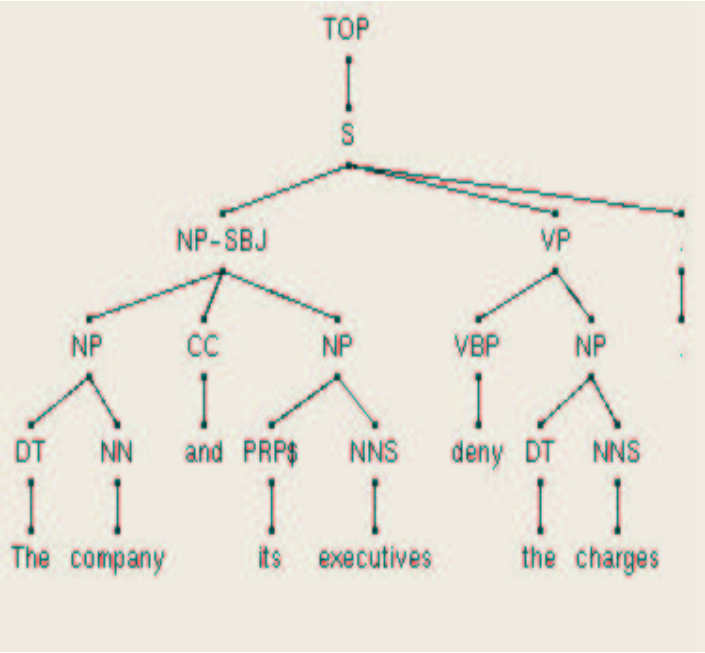
Extraction of Diagnostics (3)

Approach

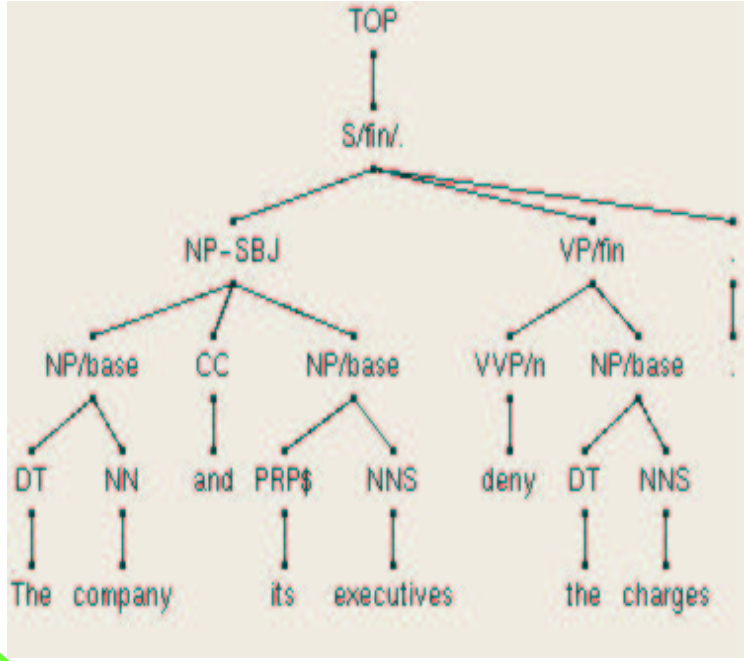
- Extraction of frames
- Acquisition of selectional preferences for identification of causative alternation
- Semi-automatic extraction of resultative constructions and *out*-prefixation

Extraction of Frames (1)

Penn-III Treebank



Penn-III Treebank & Features



Extraction of Frames (2)

Extraction of Probabilistic Context-Free Grammar from Treebank (76,144 rules)

Example:

```
5529 S/fin/. -> NP-SBJ VP/fin .
19   VP/fin  -> VVP/n NP/base
908  NP/base -> DT NNS
2733 NP/base -> PRP$ NNS
```

Extraction of Frames (3)

- Parsing of data with BitPar
- Extraction of frames from viterbi parses

Extraction of Frames (4)

Some Frame Elements:

SUBJ	:	Subject
NP	:	NP object
NP-PRD	:	NP predicative
PP-CLR	:	PP “argument” of VP
PP-LOC	:	PP locative
PRT	:	Particle
S	:	Infinitive
SBAR	:	Subordinate clauses

...

Extraction of Frames (5)

Most frequent frames of “eat”

```
337 SUBJ NP
307 SUBJ
 37  SUBJ NP PP
 25  SUBJ PP-LOC
 20  SUBJ NP PP-LOC
 18  SUBJ PRT NP
…
```

Identification of Causative Alternation

Approach

[McCarthy, 2001]

- Subcategorization frames
- Acquisition of selectional preferences at target slots
- Data similarity at target slots

Semi-Automatic Extraction

Semi-automatic extraction of

- *way*-construction (resultative)
- *out*-prefixation

from:

- corpora using the IMS Corpus Query Processor [Christ et al., 1999]
- WWW using heuristics

Classification

Objective

- Assign each verb to the subset of CTVs or NCTVs
- Identify those attributes which are relevant for the classification

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Experiment (1)

Data

- 58 verbs from literature on causative verbs
- Extraction of frames & their frequency: 1000 sentences of length <= 25 for each verb

Experiment (2)

Classification

- Decision tree learning algorithm: C4.5 [Quinlan, 1992]
- Attributes: 19
- Training data: 48 verbs
- Test data:10 verbs

Experiment (3)

Attributes & their Values

- *Way*-construction & *out*-prefixation (value: boolean):
  - < 50 occurences : no
  - >= 50 occurences: yes
- 17 most frequent frames (value: probability)

Experiment (4)

List of Attributes

- **way**
- **out**
- subj-np
- **subj**
- subj-np-pp
- subj-np-ppclr
- subj-np-pploc
- subj-prt
- subj-prt-np
- subj-pp
- subj-ppclr
- subj-ppdir
- subj-s
- subj-np-prt
- subj-sbar
- subj-np-ppdir
- subj-pploc
- subj-np-np
- subj-np-sbar

Experiment (5)

Results

- Evaluation on test data:
  38% misclassified verbs
- *Out*-prefixation best classifier

Experiment (6)

Discussion

- *out*-prefixation as best classifier
- What about the rest of diagnostics?
  - Too much noise in data?
  - C4.5 not suitable for this task?

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Future Work

- Large scale experiment for English with 1500 verbs (in preparation)
- Other classification algorithms, e.g. Support Vector Machines, Neural Networks etc.
- Experiment for Greek
- Crosslinguistic comparison

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