Natural Language Processing

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CS 365 Artificial Intelligence
Two views of Grammar

The question "How can you construct a grammar with no appeal to meaning" is wrongly put, since the implication that obviously one can construct a grammar with appeal to meaning is totally unsupported.

- Chomsky, Syntactic Structures 1957, p.93

[Cognitive grammar] takes the radical position that grammar reduces to the structuring and symbolization of conceptual content and thus has no autonomous existence at all.

- Langacker, Grammar and Conceptualization, 2000, p.3
1. Colorless green ideas sleep furiously.
2. Furiously sleep ideas green colorless.

Both are meaningless yet we can judge 1 as grammatical and 2 as ungrammatical.

Hence syntax is independent of meaning.
Probabilistic Grammar

\[ S \rightarrow NP \ VP \ [1.00] \]

\[ NP \rightarrow Pronoun \ [0.10] \]
\[ \quad \rightarrow Name \ [0.10] \]
\[ \quad \rightarrow Noun \ [0.20] \]
\[ \quad \rightarrow Article \ Noun \ [0.50] \]
\[ \quad \rightarrow NP \ PP \ [0.10] \]

\[ VP \rightarrow Verb \ [0.60] \]
\[ \quad \rightarrow VP \ NP \ [0.20] \]
\[ \quad \rightarrow VP \ PP \ [0.20] \]

\[ PP \rightarrow Preposition \ NP \ [1.00] \]
Semantics
Montagovian Semantics [1973]

From [Kohlhase]
WHO? WHAT?
WHERE? WHEN? HOW?
WHY? WHICH? HOW MUCH?
HOW MANY? HOW LONG? HOW FAR?
WHAT FOR? WHAT NEXT? THEN
WHAT? WHY ME?
Semantics First: A pathway to Cognition

Conceptual complexity
- Atomic object
- Analogy / Metaphor
  - Event -> Argument
  - Structure / Relation

Perceptual complexity
- Chase, Come closer
- In, Out, Tight, Loose
- "Turn left"
Instead of trying to produce a programme to simulate the adult mind, why not rather try to produce one which simulates the child's?

If this were then subjected to an appropriate course of education one would obtain the adult brain.

- Alan Turing
Framenet: Semantic Roles

Familiar notion in NLP

- Restaurant Frame:
  - “John ate chicken tandoori with his fingers.”

- Framenet = Comprehensive Lexicon of Frames

Semantic Roles

- The underlying relationship that a constituent has with the target word in a clause.

- Eg: *John hit Bill.*
  - Agent: John
  - Victim: Bill

- Apt for capturing semantic information -:
  - systematic method for capturing the event structure
  - the value that a role takes is independent of the syntactic structure of the sentence
Framenet

The Frame is the basic lexical structure that links:

- individual word senses,
- relationships between the senses of polysemous words,
- relationships among semantically related words
Example

Frame: Ingestion
Frame Elements:
  Core: Eater Eaten
  Peripheral: Place Implement Manner Time

John [EATER]
ate [lexical unit]
chicken tandoori [EATEN]
at the Indian Restaurant [PLACE]
with his fingers [IMPLEMENT]
Participant semantics

The locals (Ingestor) EAT mainly fish and fruits (Ingestibles).

As the house doesn`t have a dining room the family(Ingestor) eats in the large kitchen(Place).

She(Ingestor) took the ice-cream(ingestible) out of the fridge (source) and ate it.
## Frame: Ingestion

### Lexical Units for Ingestion

<table>
<thead>
<tr>
<th>English</th>
<th>Hindi</th>
<th>Bangla</th>
</tr>
</thead>
<tbody>
<tr>
<td>breakfast.v</td>
<td>नाश्ता</td>
<td>prAtarAsh v</td>
</tr>
<tr>
<td>Consume.v</td>
<td>भोग करना</td>
<td>bhog k.v</td>
</tr>
<tr>
<td>drink.v</td>
<td>पी</td>
<td>khA.v</td>
</tr>
<tr>
<td>eat.v</td>
<td>खा</td>
<td>khA.v</td>
</tr>
<tr>
<td>feast.v</td>
<td>भोज करना</td>
<td>bhoj k.v</td>
</tr>
<tr>
<td>feed.v</td>
<td>खिला</td>
<td>khAoyA.v</td>
</tr>
<tr>
<td>gulp.v</td>
<td>निगल</td>
<td>gelA.v</td>
</tr>
<tr>
<td>have.v</td>
<td>ले</td>
<td>Neo.v</td>
</tr>
<tr>
<td>munch.v</td>
<td>चवा</td>
<td>chebA.v</td>
</tr>
<tr>
<td>nibble.v</td>
<td>कुत्तर</td>
<td>ThokrA.v</td>
</tr>
<tr>
<td>sip.n</td>
<td>घूंट</td>
<td>chumuk.n</td>
</tr>
<tr>
<td>sip.v</td>
<td>घूंट लेना</td>
<td>Chumuk de.v</td>
</tr>
</tbody>
</table>
Parallel Sentence Analysis

As the house doesn’t have a dining room, the family [EATER] eat [Lexical Unit] in the large kitchen [PLACE].

क्योंकि घर में भोजन कृक्ष नहीं है, परिवार के लोग [EATER] बड़े रसोयी [PLACE] में खाते हैं [LU]

bARite bhojan kakSha nei tAi paribArer sabAi [EATER] baRa rAnnAghare [PLACE] khAy [LU].
Other Semantic Categorization Schemes:

FrameNet:
- Placing: put, place
- Filling: load, spray, fill, festoon, encircle
- Containing

Levin (1993):
- Filling: festoon, fill, encircle, contain
- Spraying: load, spray
- Putting: place, put, butter, caulk

CONTINUOUS LOCATION
PATEG
Communication Verbs

Figure 2 Communication verbs in Levin

Figure 3 Communication verbs in FrameNet
PropBank / VerbNet

**eat-39.1**

**Members**
- [drink(1 2), eat(1 2 3)]

**Thematic Roles**
- Agent[+animate]
- Patient[+comestible]
- Instrument[+concrete]

**Frames**
- Basic Transitive ()
  "Cynthia ate the peach"
  Agent V Patient
- Unspecified Object Alternation ()
  "Cynthia ate"
  Agent V
- Conative ()
  "Cynthia ate at the peach"
  Agent V Prep(at) Patient
- Resultative ()
  "Cynthia ate herself sick"
  Agent V Oblique Adj
Semantic Tagging

- Probabilistic Role Assignment based on FrameNet Corpus [Gildea, 2002]
- **Linking Theory**: “There is a unique relationship between the syntactic and semantic structure of a sentence”
- Based on features extracted from parse tree, and probability (A statistical approach)
Grounded Language Learning
Heider/Simmel video

Narrative:
the little square
hit the big square

[Heider and Simmel 1944]
video recreated by Bridgette Hard
at Barbara Tversky lab, Stanford U
Visual attention model

Maji, Singh and Mukerjee 2005
Narratives: “Chase” Video

Wide variation in Narratives:

1. Large square corners the little circle
2. Big square approaches little circle
3. Little square is moving away from the big square; and objects inside are moving closer together
4. Big block tries to go after little circle

Video and commentaries from Tversky Group, Stanford University
Noun Learning

Circle

Big Square

Little Square

Door
Based on intervals where the attended agent is ending “in” the box.
Trajectories ending Outside

In to Out with verbs

Association

through | busts | breaks | of | out

Learning Containment Spatial Descriptors
Recognition from real video
Learning Agent Appearances
Shape + Haar clusters

Guha and Nandi 09 model
**PHOW clusters**

<table>
<thead>
<tr>
<th>C16</th>
<th>![Image of C16 clusters]</th>
</tr>
</thead>
<tbody>
<tr>
<td>C19</td>
<td>![Image of C19 clusters]</td>
</tr>
<tr>
<td>C21</td>
<td>![Image of C21 clusters]</td>
</tr>
<tr>
<td>C23</td>
<td>![Image of C23 clusters]</td>
</tr>
<tr>
<td>C26</td>
<td>![Image of C26 clusters]</td>
</tr>
<tr>
<td>C27</td>
<td>![Image of C27 clusters]</td>
</tr>
<tr>
<td>C29</td>
<td>![Image of C29 clusters]</td>
</tr>
</tbody>
</table>
Shape + Haar clusters

Guha and Nandi 09 model
Unsupervised clustering results

Guha and Nandi 09 model
### Sample Commentaries

<table>
<thead>
<tr>
<th>S1</th>
<th>Sentence</th>
<th>Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>एक बाइक गयी अभी</td>
<td>1158 -</td>
</tr>
<tr>
<td></td>
<td>ek bAik gayI abhI</td>
<td>1224</td>
</tr>
<tr>
<td></td>
<td>One bike go+past now.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A bike went just now.</td>
<td></td>
</tr>
</tbody>
</table>

| S2   | साइकल रिक्षा पे एक आदमी चढ़ा           | 1216 -   |
|      | sAiD meN sAikal rikshA pe ek ADamI chaDhA | 1382      |
|      | Side [on] one cycle rickshaw [on] one man climb+past |           |
|      | A man climbed on a cycle rickshaw           |           |
|      | on the side (of the scene).                 |           |

| S3   | साइकल बाइक आये जा रहे हैं               | 1239 -   |
|      | sAikal bAik Aye ja rahe haiN.              | 1354      |
|      | Bicycles bikes come+pp go+pp are.          |           |
|      | Bicycles, bikes are coming and going.      |           |
## Word-Object Associations

**Narrative:**

the little square hit the big square

| Hindi phrase(l) | Transliteration | Gloss     | $P(l|γ)$  |
|-----------------|-----------------|-----------|-----------|
| **γ=HUMAN**     |                 |           |           |
| जा              | jA              | going     | 0.0391    |
| डेम्पी          | Tempo           | tempo     | 0.0204    |
| सड़क           | saDak           | road      | 0.0187    |
| **γ=MOTORCYCLE**|                 |           |           |
| जा              | jA              | going     | 0.0295    |
| लोग            | log             | people    | 0.0202    |
| फिर            | phir            | again     | 0.0191    |
| **γ=BICYCLE**   |                 |           |           |
| सड़क           | sAikal          | bicycle   | 0.0699    |
| जा              | jA              | going     | 0.0553    |
| लोग            | log             | people    | 0.0444    |
| **γ=TEMPO**     |                 |           |           |
| जा              | jA              | going     | 0.0425    |
| लोग            | log             | people    | 0.0208    |
| ड्रूक           | Trak            | truck     | 0.0182    |
| **γ=TRUCK (Lorry)**|             |           |           |
| ड्रूक           | Trak            | truck     | 0.0374    |
| लोग            | log             | people    | 0.0228    |
| फिर            | phir            | again     | 0.0216    |
| **γ=CAR**       |                 |           |           |
| कार             | kAr             | car       | 0.0402    |
| जा              | jA              | going     | 0.0342    |
| ड्रूक           | Trak            | truck     | 0.0254    |