Deep Understanding and Textual Entailment

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Entailment requires knowledge

Lots of it!

e.g.,

- when you fall asleep, you were awake before
- if a building burns down, it is destroyed
- if you buy something, you own it
- driving a car requires a key
Much Recent Work on Learning by Reading

Levels of Learning

- simple facts – given an ontology instantiate one or more relations (e.g., Athens is in Greece, Chicago is in the US, ...)
- complex facts - given an ontology, learn compositional knowledge (e.g., learn the route to get to a restaurant)
- new words, concepts and relations - Extending our ontology as we learn new facts (e.g., learn about plumbing)
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Our Approach

- Learn definitions of concepts from online sources, bootstrapping from a hand-built deep understanding system
What is Deep understanding?

Students develop deep understanding when they grasp the relatively complex relationships between the central concepts of a topic or discipline. Instead of being able to recite only fragmented pieces of information, they understand the topic in a relatively systematic, integrated or holistic way. As a result of their deep understanding, they can produce new knowledge by discovering relationships, solving problems, constructing explanations and drawing conclusions.

Students have only shallow understanding when they do not or cannot use knowledge to make clear distinctions, present arguments, solve problems or develop more complex understanding of other related phenomena.

Dept. of Education, Queensland
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in other words,

connecting language to other cognitive abilities:
Knowledge, reasoning, action, learning, ...
Building a Knowledge Base from definitions...

**Bootstrap from a hand-built deep understanding system**
- TRIPS - 2500+ concept upper ontology, semantic roles, extensive grammar and core vocabulary, and wordnet mappings
- Why? a core competence in linking NLP & KR in order to learn new concepts

**Build new concepts compositionally**
- new concepts expressed in OWL-DL (Description Logic)
- Why? OWL designed to express complex compositional concepts; multiple inheritance; subsumption provide automatic classification of new concepts

**Use existing sources for concept definitions**
- Wordnet glosses
- Why? extensive source of definitions, and used in many applications
TRIPS Language Processing

“Let me show you how to find a restaurant”

Hand-built Grammar of English

Compiled Lexicon: patterns with selectional restrictions/preferences

Hand-built Core Lexicon: subcat patterns sense=concept in ontology linking rules

Chart Parser

Hand-built Generic ~ 2500 Top-level Ontology

LF graph
But everyone knows deep understanding is not possible*

Deep understanding only works in narrow domains using lots of hand-engineering!

Deep understanding is too brittle!

Deep understanding is not possible without solving the entire AI problem!
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- Deep understanding only works in narrow domains using lots of hand-engineering!
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*Not!
"Advanced Medical paid $106 million in cash for its share in a unit of Henley 's Fisher Scientific subsidiary."
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Utilizing statistical preprocessing: TextTagger

TextTagger preprocesses text using a wide range of resources

Named entity recognition
Stanford NER (-> ONT::ORGANIZATION, ONT::PERSON, ONT::GEOGRAPHIC-REGION)
Geographical Names (GNIS) -> ONT::GEOGRAPHIC-REGION
Street Address Recognizer
Alphanumeric, e.g., “AK-47”

Part of speech tagging
Stanford POS: emits both Penn treebank tags and TRIPS tags

Structural Analysis
Sentence and clause boundary detection and segmentation
Constituent bracketing (Stanford Parser)

Alternate spellings
e.g., behaviour, behavior

multi-word recognition based on Wordnet

... Ace Medical cooperating with us in ....
(phrase "Ace Medical" :frame (21 32) :tag (W::NAME) :ont-sense ONT::CORPORATION)
(word "cooperating" :frame (33 42) :tag (W::V) :penn-tag VBG :alt ("co-operating"))
(word "with" :frame (43 47) :tag (W::PREP W::ADV) :penn-tag IN)
(word "us" :frame (48 50) :tag (W::PRO) :penn-tag PRP)
(prefer (% W::NP) :frame (48 50) :score 8.799)
(prefer (% W::PP) :frame (43 50) :score 12.066)
“Cooperates” is not in core lexicon

(word "cooperating" :frame (33 42) :tag (W::V) :penn-tag VBG :alt ("co-operating"))

“co-operating” is also not in lexicon

Look up in Wordnet

S: (v) collaborate, join forces, cooperate, get together (work together on a common enterprise of project) "The soprano and the pianist did not get together very well"; "We joined forces with another research group"

• S: (v) work (exert oneself by doing mental or physical work for a purpose or out of necessity) "I will work hard to improve my grades"

Map to TRIPS Ontology

{collaborate, join forces, ...} no mapping, move up wordnet hierarchy ...

{work} work %2:41:02:: -> ONT::WORKING

which has essential role AGENT (+intentional object)
we adopt the linking rules for the words with a sense ONT::WORKING

Derive Features

Using penn tag VBG, we set the VFORM feature to “-ing”
From ONT::WORKING class and inheritance, we get other feature values
e.g., TIME-SPAN=EXTENDED, ASPECT=UNBOUNDED, ...

We now have a semantic lexical entry for “cooperates”
Robustness: Heuristic Extraction

Find least-cost path from start to end
where cost depends on type of constituent, score assigned by the parsing, ...

Assemble logical forms from fragments
Try to connect using discourse processing

He ran and to the store

Friday, July 8, 2011
Robustness: Heuristic Extraction

Find least-cost path from start to end
where cost depends on type of constituent, score assigned by the parsing, ...

Assemble logical forms from fragments
Try to connect using discourse processing
A Semantic Evaluation

Gold Graph

Test Graph

\( Nscore_A(n) = 2 \) if the indices match, and both the node type and sense in the label of node \( n \) matches the label of node \( A(n) \), 1 if one of them matches, and 0 otherwise.

\( Escore_A(e) = 1 \) if \( e \) connect nodes \( n1 \) and \( n2 \), and there is an edge between \( A(n1) \) and \( A(n2) \) with same label, 0 otherwise.

\( Gscore(G,T) = \max_A(\sum_{n,e}(Nscore_A(n) + Escore_A(e))) \)

Precision(G,T) = \( Gscore(G,T)/Gscore(T,T) \)

Recall(G,T) = \( Gscore(G,T)/Gscore(G,G) \)
Example 1: STEP ’09

Six paragraphs submitted by six different research groups

Gold standard built by hand and verified, including word senses (all words including quantifiers, predicates, operators, ...), semantic roles

But not “deeper” content, including coreference, temporal relations, etc

<table>
<thead>
<tr>
<th></th>
<th>Initial Baseline System</th>
<th>Baseline System II</th>
<th>w/ NER, POS, and UKW lookup</th>
<th>w/ constituent advice from Stanford Parser</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prec.</strong></td>
<td>61.40%</td>
<td>74.4%</td>
<td>78.2%</td>
<td>79.0%</td>
</tr>
<tr>
<td><strong>Recall</strong></td>
<td>67.20%</td>
<td>74.4%</td>
<td>82.6%</td>
<td>82.8%</td>
</tr>
<tr>
<td><strong>F-score</strong></td>
<td>64.2%</td>
<td>74.4%</td>
<td>80.3%</td>
<td>80.9%</td>
</tr>
</tbody>
</table>

Amid the tightly packed row houses of North Philadelphia, a pioneering urban farm is providing fresh local food for a community that often lacks it, and making money in the process. Greensgrow, a one-acre plot of raised beds and greenhouses on the site of a former steel-galvanizing factory, is turning a profit by selling its own vegetables and herbs as well as a range of produce from local growers, and by running a nursery selling plants and seedlings. The farm earned about $10,000 on revenue of $450,000 in 2007, and hopes to make a profit of 5 percent on $650,000 in revenue in this, its 10th year, so it can open another operation elsewhere in Philadelphia.
## Performance in TempEval-2 (2010)

<table>
<thead>
<tr>
<th>Task</th>
<th>TRIOS Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp exp extraction</td>
<td>Second best</td>
</tr>
<tr>
<td>Event extraction</td>
<td>Third best</td>
</tr>
<tr>
<td>Temp relation event and temp exp</td>
<td>Best</td>
</tr>
<tr>
<td>Temp relation event and DCT</td>
<td>Second best</td>
</tr>
<tr>
<td>Temp relation main events consecutive sentence</td>
<td>Best</td>
</tr>
<tr>
<td>Temp relation events in same sentence</td>
<td>Second best</td>
</tr>
</tbody>
</table>

Table 1: Performance of TRIOS in TempEval-2

- **TRIOS** = TRIPS+MLN+CRF to identify events and temporal relations in open text
- Best on three of the six tasks
- Best system of those that performed all 6 tasks
- Only system that worked from raw text rather than corpus-provided features
Extracting Knowledge from WordNet
Using Wordnet as a knowledge source

What WordNet says about Sleeping ...
Weaknesses of Wordnet as a KR

Shallow hierarchies except for nouns
Weaknesses of Wordnet as a KR

Shallow hierarchies except for nouns
Many top-level (uninterpreted) nodes
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Fine-grained near synonyms
Weaknesses of Wordnet as a KR

Shallow hierarchies except for nouns
Many top-level (uninterpreted) nodes
Fine-grained near synonyms
Unclear what hierarchies mean
Glosses in Wordnet have much richer information.

<table>
<thead>
<tr>
<th>Synset Name</th>
<th>Gloss</th>
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<tbody>
<tr>
<td>wake_up%2:29:00</td>
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Reading this, we (as people) learn facts such as:
- before falling asleep, you are awake, and afterwards you are asleep
- if you awaken someone then they wake up
Our target: OWL-DL

OWL-DL is designed to be expressive as possible while still allowing provably efficient reasoning algorithms.

Concepts are arbitrary compositions of constraints, such as:

- **subtype constraints**: e.g.,
  - HUMAN is a subtype of ANIMAL
  - All LIVING-THINGS are either a PLANT or ANIMAL

- **role constraints**, e.g.,
  - whose sex role is either MALE or FEMALE
  - who has exactly one head
  - whose every child is a HUMAN

- **and equality**, e.g.,
  - BACHELOR = [PERSON :sex MALE :marital-status SINGLE]
Understanding Glosses

“do away with, cause the destruction or undoing of”

“destroy completely; damage irreparably”

“defeat soundly”

“put (an animal) to death”
Understanding Glosses

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Multiple definitions in one gloss
Understanding Glosses

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Disjunctions and conjunctions
Understanding Glosses

“do away with, cause the destruction or undoing of”
“destroy completely; damage irreparably”
“defeat soundly”
“put (an animal) to death”

Multiple definitions in one gloss
Disjunctions and conjunctions
Gaps & ellipsis
An Example: Defining a new concept

"keep up" == "prevent from going to bed at night"

Lexical Processing
look up in TRIPS lexicon
prefer senses that correspond to tagged WN senses
If no entry in TRIPS, build entry based on wordnet mapping

Parsing
(F ont::HINDERING prevent%2:41:00) :effect
(F ont::SITUATION-ROOT go_to_bed%2:29:00) :time-clock-rel
(BARE ont::TIME-INTERVAL night%1:28:00)

IMPRO agent)

IMPRO affected)
Determining Roles

“Keep up” = “prevent from going to bed”

- acquires :agent and :affected role from ONT::HINDERING
- but no :effect role as that is explicitly filled in the definition

We verify the hypothesized roles by parsing the examples that Wordnet provides.
Constructing the Definition

\[
\text{Keep\_up}\%2:29:00 \subseteq \text{Prevent}\%2:41:00 \cap \exists \text{agent.Intentional\_Agent} \cap \exists \text{affected.Intentional\_Agent} \\
\cap \exists \text{effect.}[\text{Go\_to\_bed}\%2:29:00 \cap \exists \text{at-time.Night}\%1:28:00]
\]
Details: Constructing a Definition in OWL

Constructing the Definition

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Or as a picture ...
## Compositional Construction of KB

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Compositional Construction of KB

\[\text{wake-up}^{2:29:00} = \text{to stop}^{2:42:00} \text{ sleeping}^{1:09:00}\]
Compositional Construction of KB

sleeping%1:09:00 = the state%1:03:00 of being asleep%4:02:00

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Compositional Construction of KB

asleep%3:00:00 = in a state%1:03:00 of sleep%1:26:00

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A Slightly Simplified KB from the definitions

- **prepare%2:30:00**: purpose E
- **go_to_bed%2:29:00**: cause E
- **prevent%2:41:00**: effect E
- **keep_up%2:29:00**: person
- **change%2:30:02**: from X to Y
- **remain%2:42:01**: effect P
- **sleeper%1:18:00**: agent-of E
- **waking%1:09:00**: HAVE-PROPERTY:property P
- **state%1:03:00**: of X
- **awake%3:00:00**: state of X
- **asleep%3:00:00**: state of X
- **sleep%1:26:00**: state of X
- **STOP**: in%4:02:01:val X
- **in%4:02:01**: val X
- **stay%1:03:00**: of X
- **sleep%1:26:00**: sleep%1:26:00
- **not**: arg P
- **awake%3:00:00**: awake%3:00:00
- **asleep%3:00:00**: asleep%3:00:00
- **keep_up%2:29:00**: sleeper%1:18:00
- **prevent%2:41:00**: effect E
- **STOP**: stop%2:38:00:effect E
- **rest%1:03:00**: person
- **stop%2:38:00**: stop%2:38:00
- **wake_up%2:29:00**: wake_up%2:29:00
- **person%1:03:00**: person%1:03:00
- **rester%1:18:00**: rester%1:18:00
A Slightly Simplified KB from the definitions

Once we have this, what can we do with it?

Not much yet! Need a model of entailment
Filling the gaps

Note that we didn’t expand out definitions of terms like stop, change, cause, remain, ...
Filling the gaps

Note that we didn’t expand out definitions of terms like stop, change, cause, remain, ...

Why?

stop = come to a halt, stop moving
halt = the event of something ending
ending = be the end of
end = the point in time when something ends

We don’t learn what stopping means from reading!!
Inference

Need an assertional layer to capture common-sense knowledge about basic causality, time, etc.

Use variant Allen's temporal logic

T(<concept>, <time>)

meaning <concept> HOLDS/OCCURS at time t
Axiomatization

“when e stops it isn’t occurring any more”
$$\neg T([\text{stop%2:38:00 :effect e}], t) \supset \exists t'. \text{Meets}(t, t') \wedge \neg T(e, t')$$

“If X is in a state of e, the e is occurring”
$$T([\text{in%4:02:01 :val [state%1:03:00 :of e]}], t) \supset T(e, t)$$

“If X changes to state Z, then X in in state Z afterwards”
$$T([\text{change%2:30:02 :to z}], t) \supset \exists t'. t \text{ meets } t' \wedge T(z, t')$$
Implementation

Common-sense axioms encoded in SWRL

Entailments arise as events are instantiated:

- create event from parse
- repeat as needed
- instantiate new events entailed from definitions
- apply SWRL rules to new events
Simplified Example

“John fell asleep”

Adding Logical Form

Fall_Asleep%2:29:00
Simplified Example: "John fell asleep"

- **Fall_Asleep**: to-state of **state**: to **waking**
- **Fall_Asleep**: from-state of **state**: from **waking**

Timeline: 
- **Fall_Asleep**: 2:29:00
- **waking**: 1:09:00

**Concepts**

- **Fall_Asleep**: 2:29:00
- **waking**: 1:09:00

Friday, July 8, 2011
Simplified Example

“John fell asleep”

State%2:29:00 : of sleep%2:29:0

Fall_Asleep%2:29:00

waking%1:09:00

from-state

to-state

meets

meets

Concepts

Timeline

Friday, July 8, 2011
Simplified Example

"John fell asleep"

Timeline

Concepts

Friday, July 8, 2011
“John fell asleep”

- **Sleep**
  - **Fall_Asleep%2:29:00**
  - **state%2:29:00 :of sleep%2:29:0**
  - **waking%1:09:00**

- **SWRL inference**
  - same-time
  - meets
  - to-state
  - from-state
  - meets

**Concepts**

**Timeline**

- **waking%1:09:00**
- **Fall_Asleep%2:29:00**
- **state%2:29:00 :of sleep%2:29:0**
Entailments from the KB

you can’t be awake and asleep at the same time

after falling asleep, you are asleep

before falling asleep, you are awake

after waking up, you are awake

But not “if you are kept up, you are awake”
keep up = prevent from going to bed
Another Example: knowledge about cooking

The WordNet hierarchy for some selected cooking terms (out of 7318!)
Another Example: knowledge about cooking

The WordNet hierarchy for some selected cooking terms (out of 7318!)

Augmented by understanding the glosses
Ultimate evaluation is a demonstration the knowledge we learn is useful

- entailment tests, reading comprehension tests, ...
- improved language handling: word sense disambiguation, discourse, ...

Not there yet, so some preliminary explorations...

- do the wordnet hierarchies provide useful knowledge?
- can we build reasonable knowledge using glosses
Example: Exploring the Noun Hierarchy

The noun hierarchy is the best developed in Wordnet, by far, so it a good place to explore capabilities.

We evaluate our ability to understand glosses by building a new hierarchy based on glosses alone.

Questions:

- can parsing glosses recover the existing hierarchical information in WordNet?
Learning Hierarchical Relations

Experiment

- randomly select 100 nouns, with 20 known WN subtype pairs
- collect the glosses, and definitions of concepts used in the glosses
- process and test subsumption between each pair of concepts
- use WN hierarchy as the gold standard
Learning Hierarchical Relations

Experiment

- randomly select 100 nouns, with 20 known WN subtype pairs
- collect the glosses, and definitions of concepts used in the glosses
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Initial Results

precision: 100%
recall 44%

<table>
<thead>
<tr>
<th>TRIPS</th>
<th>TRUE</th>
<th>FALSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>X subtype Y</td>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td>no reln</td>
<td>9975</td>
<td>16</td>
</tr>
</tbody>
</table>
Problems Revealed

Distinguishing being necessary and necessary & sufficient conditions

Complex definitions, requiring better parsing and/or more common sense

Questionable definitions/relations in WordNet

- Distinguishing between necessary and necessary & sufficient conditions
- Complex definitions, requiring better parsing and/or more common sense
- Questionable definitions/relations in WordNet
Example: Filling in the Wordnet Verb Hierarchy

- It's not a hierarchy, but a forest of subtrees
- 550+ “top level” verbs in WN that have no supertypes

begin%2-30-01

leave_behind%2-30-03

go_to_bed%2-29-0

fracture%2-29-01

leak%2::30:00

turn_to%2-30-0

carry_to_term%2-29-00

disappear%2-30-00

oversleep%2-29-0

appear%2-30-02
Can we create a useful hierarchy from glosses?

An Exploration

- select 50 “top-level” verb senses from Wordnet
- classify them into the TRIPS upper ontology based on the glosses
Can we create a useful hierarchy from glosses?

An Exploration
- select 50 “top-level” verb senses from Wordnet
- classify them into the TRIPS upper ontology based on the glosses

14 verbs involving change
Verb Hierarchies

5 verbs of causation

- ont::cause-make
- ont::cause-action
- ont::cause-make*let
- ont::cause-make*prepare
- ont::create
- form %2-41-00
- be_active%2-29-03
- settle%2-30-01
- go_to_bed%2-29-0

ont::cause-come-from

ONT::MOTION

4 verbs of motion

- ont::arriving
- ont::come
- ont::come-from
- click%2-31-13
- issue%2-30-00
- appear%2-30-02
- remove%2-30-0

ONT::RELINQUISH

4 verbs of relinquishing

- ont::discarding
- ont::giving
- ont::supply
- ont::lose
- exhaust2-29-0
- remove-2-30-02
- disappear%2-30-00
- treat%2-29-0
Can we make this work?
1. Better Deep Parsing

**Better handling of conjunctions/disjunctions**

“highly seasoned Mediterranean soup or stew made of several kinds of fish and shellfish with tomatoes and onions or leeks and seasoned with saffron and garlic and herbs”

Current approach: 1) try full parse, 2) simplification edits, 3) robust extraction

What’s needed: better preprocessing to tag scope of conjuncts using similarity measures

**Better word sense disambiguation**

Current approach: 1) prefer explicit wordnet tag with backoff, 2) prefer most common senses in each syntactic class

Bootstrapping common semantic combinations that provide preferences

**Better semantic role assignment/TRIPS ontology**

Reworking roles in context of reworking upper ontology (based on GUM)
2. Cleaning up the Knowledge Acquired

Wordnet has many redundant concepts, e.g.,

- “young person” -> young_person%1-18-00 “a young person (especially a young man or boy)

approach

- check if meaning of the phrase subsumes the meaning of the gloss
- if so, we can remove the defn (“young person” as a multiword)
- “go to bed” -> go_to_bed%2-29-00 is retained since no meaning of “go” and “bed” can subsume “prepare for sleep”

Other senses may remain, but to a composite concept, not an atomic one

- “spring chicken” (a synonym of “young person”) -> PERSON ^ YOUNG
Once definitions are in OWL, we can define a semantic similarity metric between concepts:

- A combination of true subsumption (rare), class similarity ("size" of most specific subsuming class), and role similarity (requiring recursive class similarity).

Standard clustering algorithms can then suggest sense merges, and we use KB to derive a new common subsuming class that captures the new sense.
4. Wordnet as a Source of Knowledge?

Wordnet misses much commonsense knowledge, e.g.,

- keep_up%2:29:00 = “to be asleep%3:00:00”
- asleep%3:00:00 = “into a sleeping state”
- but what is sleeping???

Unhelpful definitions

- Circular Definitions
  - stop%2:41:00 = “to stop from happening or developing”!

Still, Wordnet includes large amounts of knowledge if it can be extracted intelligently

- And there are many other sources of definitions (other dictionaries, Wikipedia, ...)
Concluding Thoughts

We hope we have established the feasibility of building rich knowledge bases for entailment from online resources such as Wordnet and dictionaries.

To obtain high quality knowledge we need:

- better handling of complex phenomena in parsing - especially conjunction and ellipsis
- reasoning-based cleaning techniques to detect and resolve inconsistencies, and generalize knowledge
Try it out!

TRIPS Parser Web Interface

he seems to have a headache

Tree contents: Phrase-level nodes only
Tree format: LinGO-like table diagram
LF format: SVG diagram

Words

HE SEEMS TO HAVE A HEADACHE

Logical Form

(SPEECHACT SA_TELL)

(CONTENT)

(F (:* APPEARS-TO-HAVE-PROPERTY SEEM))

(EFFECT)

(F (:* HAVE-EXPERIENCE HAVE))

(THEME)

(PRES)

(A (:* PHYSICAL-SYMPTOM HEADACHE))

(BASE)

(PRO (:* PERSON HE))

(PROFORM)

HE
Try it out!

TRIPS Word Lookup

stop

- Noun Classes:
  - **ONT::location** (show synset) (show ancestors)
    Example: go to this stop

- Verb Classes:
  - **ONT::stop** (show synset) (show ancestors)
    Frames:
      - cause-effect-xp-templ (xp (% vp (vform ing)))
        Example: he stopped the rioting
      - affected-templ
        Example: he/the truck stopped
      - affected-effect-xp-templ (xp (% vp (vform ing)))
        Example: the computers/managers stopped working
      - cause-affected-xp-templ
        Example: he/the storm stopped the fair/the truck
      - effect-templ
        Example: the rioting stopped
      - cause-effect-affected-objcontrol-templ (xp (% cp (ctype s-from-ing)))
        Example: the hospital stops visitors from smoking

Data files last modified: Sun Jul 3 03:19:02 2011

www.cs.rochester.edu/research/trips/lexicon/browse-ont-lex.html

TRIPS Ontology Browser

**V** root

- +
  - **V** any-sem
    - +
      - **V** any-time-object
        > **any-time-object**
        - **V** referential-sem
          > **any-time-object** (entity%1:03:00) (show words)
            > abstract-object (psychological_feature%1:03:00,
              abstraction%1:03:00)
            > part (part%1:24:00) (show words)
            > phys-object (object%1:03:00) (show words)
        - **V** situation-root
          - +
            - accommodate (adapt%2:30:01) (show words)
              > acquire (take%2:33:08, take%2:35:14, take%2:40:08,
                subscribe%2:40:00, claim%2:32:01, accept%2:40:00,
                take%2:40:00, assume%2:30:00, get%2:40:00) (show words)
              - **V** acting (act%2:29:00, act%1:03:00) (show words)
                > cause-effect (causal_agent%1:03:00, cause%1:10:00,
                  cause%1:11:00, cause%2:36:00, produce%2:36:00)
                  (show words)
                - +
                  - **V** inhibit-effect
                    - disable (show words)
                      > hindering (restrain%2:41:01, prevent%2:41:00,
                        restrict%2:30:00, prevent%2:41:01,
                        handicap%2:33:00) (show words)
                      - prevent (prevent%2:41:00, prevent%2:41:01,
                        prevention%1:04:00) (show words)
                      - prohibit (show words)
                      - refuse (deny%2:40:00) (show words)
                      - stop (discontinue%2:42:00, end%2:42:00,
                        run_out%2:42:00) (show words)
                    - +
                      - **V** activity (activity%1:04:00)
                        > activity-ongoing (show words)
                        - +
                          - **V** activity-ongoing (show words)
                            > activity-experiences (show words)