Designing Abstract Meaning Representations for Machine Translation

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( Kevin Knight & Claire Bonial)
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What is meaning?

… just piling up words, one after the other, won't do much of anything until something else has been added.

*Stanley Fish, How to Write a Sentence, 2011*

- And the words slide into the slots ordained by syntax, and glitter as with atmospheric dust with those impurities which we call meaning.

*Anthony Burgess, Enderby Outside, 1968*
How do we sprinkle atmospheric dust?

- Some of the challenges
- AMR
- Challenges it addresses
- Challenges it doesn’t
- What about Machine Translation?
Challenges

- Sense distinctions
- Semantic similarity
- Metaphors and world knowledge
- Constructions
- New usages
- Coercion, metonymy, implicit arguments, …
AMR development

- ISI, Colorado, LDC, SDL
  - Creating a large-scale semantics bank
  - “Abstract Meaning Representation for Sembanking”,
    - Banarescu, C. Bonial, S. Cai, M. Georgescu, K. Griffitt, U. Hermjakob, K. Knight, P. Koehn, M. Palmer, and N. Schneider,
  - LAW 2013

- Simple structures, like Penn Treebank

- Goal is supporting research in:
  - semantic parsing
  - natural language generation
  - machine translation
What content goes into the meaning representation?
- Linguistic annotation

**Meaning-based MT**

<table>
<thead>
<tr>
<th>source string</th>
<th>source tree</th>
<th>meaning representation</th>
<th>target tree</th>
<th>target string</th>
</tr>
</thead>
</table>

- today’s focus
"The boy wants to go."

LOGICAL FORM

\[ \exists w, b, g : \text{instance}(w, \text{WANT}) \land \text{instance}(g, \text{GO}) \land \text{instance}(b, \text{BOY}) \land \text{agent}(w, b) \land \text{patient}(w, g) \land \text{agent}(g, b) \]

PATH EQUATIONS

\[
\begin{align*}
(x_0 \text{ instance}) &= \text{WANT} \\
(x_1 \text{ instance}) &= \text{BOY} \\
(x_2 \text{ instance}) &= \text{GO} \\
(x_0 \text{ agent}) &= x_1 \\
(x_0 \text{ patient}) &= x_2 \\
(x_2 \text{ agent}) &= x_1
\end{align*}
\]

DIRECTED ACYCLIC GRAPH

FEATURE STRUCTURE

\[
\begin{align*}
\text{instance: WANT} \\
\text{agent: 1} & \quad \text{instance: BOY} \\
\text{patient:} & \quad \text{instance: GO} \\
\text{agent: 1}
\end{align*}
\]
Semantic Representation

**LOGICAL FORM**

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**DIRECTED ACYCLIC GRAPH**

**PENMAN**

\[
\text{LOGICAL FORM} \\
\text{PATH EQUATIONS} \\
\text{DIRECTED ACYCLIC GRAPH} \\
\text{FEATURE STRUCTURE}
\]

\[
\text{instance: WANT} \\
\text{agent: 1} \\
\text{patient: instance: BOY} \\
\text{instance: GO} \\
\text{agent: 1}
\]

"The boy wants to go."
"The boy wants to go."

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(x0 \text{ patent}) &= x2 \\
(x2 \text{ agent}) &= x1
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FEATURE STRUCTURE

- **instance**: WANT
- **agent**: 1
  - **instance**: BOY
- **patient**: 1
  - **instance**: GO
Abstract Meaning Representation (AMR)

- How to represent the meanings of sentences?
- Which concepts and relations?
- How to put them together?

- First guidelines released April 24, 2012
- 100 sentences from WSJ
- 244 sentences from webtext, 80 with consensus agreement
- The Little Prince, etc.
Abstract Meaning Representation (AMR)

- Basic “who-is-doing-what-to-whom”
- Cover all sentence content in single, rooted structure
- Builds upon PropBank
  - Uses PB rolesets: e.g. describe.01
    - Arg0: describer
    - Arg1: thing described
    - Arg2: secondary attribute, described-as
  - http://verbs.colorado.edu/propbank/framesets-english/
Abstract Meaning Representation (AMR)

- AMR composed of concepts and relations, not nouns and verbs
  - Currently ~100 relations, plus inverses
- AMR is not enslaved to syntax, or even mildly indentured:

  He described her as a genius.  (d / describe-01
  As he described her, she is a genius.  :ARG0 (h / he)
  His description of her: a genius.  :ARG1 (s / she)
  :ARG2 (g / genius))
AMR vs. PB

PropBank differences, 2 structures:

Describe-01: same except for empty ARG2
Be-01: she-ARG1, genius-ARG2, as he described her-ADV
Single rooted structures, abstracts away from surface syntax

(s / see-01
   :ARG0 (b / boy)
   :ARG1 (g / girl
      :ARG0-of (w / want-01
         :ARG1 b))

- The boy saw the girl who wanted him.
- The boy saw the girl who he was wanted by.
- The girl who wanted the boy was seen by him.
Maximal Use of PropBank Frame Files

He was not aware of research on smokers of the Kent cigarettes.

(r / realize-01
  :polarity -
  :ARG0 (h / he)
  :ARG1 (r3 / research-01
    :ARG1 (p4 / person
      :ARG0-of (s / smoke-02
        :ARG1 (c2 / cigarette
          :ARG1 (k / name
            :op1 "Kent"))))))

To get to canonical concept, we stem to English verbs, where PropBank arguments are best described.

General direction of stemming:
  adverb → adjective → noun → verb
“John could not have heard about the professor’s creation of the microbial viruses that Mary sold to Russia yesterday.”

(p2 / possible
  :polarity -
  :domain (h / hear-01
    :ARG0 (p / person
      :name (n / name :op1 "John")
    )
    :ARG1 (c / create-01
      :ARG0 (p3 / professor)
      :ARG1 (v / virus
        :mod (m / microbe)
      )
      :ARG1-of (s / sell-01
        :ARG0 (p4 / person
          :name (n2 / name :op1 "Mary")
        )
        :ARG2 (c2 / country
          :name (n3 / name :op1 "Russia")
        )
        :time (y / yesterday)
      )
    )
  )
How is it really different from PropBank?

- Numbered Args, + ArgMs:
  - COM: Comitative
  - LOC: Locative
  - DIR: Directional
  - GOL: Goal
  - MNR: Manner
  - TMP: Temporal
  - EXT: Extent
  - REC: Reciprocals
  - PRD: Secondary Predication
  - PRP: Purpose
  - CAU: Cause
  - DIS: Discourse
  - ADV: Adverbials
  - ADJ: Adjectival
  - MOD: Modal
  - NEG: Negation
  - DSP: Direct Speech
How is it really different from PropBank? More semantic relations

- LOTS of additional relations/concepts in addition to numbered args, modifier tags of PB (types of ArgM’s):
  - **Quantities:** :quant :unit :scale
  - **Ops:** :op1 :op2 :op3 :op4…
How is it really different from PropBank? Discourse relations

- Introduction of additional discourse elements:
  - *But* = contrast: “The House has voted to raise the ceiling to $3.1 trillion, but the Senate isn't expected to act until next week at the earliest.”
  - *Even though* = concession: “Workers described ‘clouds of blue dust’ that hung over parts of the factory, even though exhaust fans ventilated the area.”

- Penn Discourse Treebank – inter-sentential
- AMR – intra-sentential
How is it really different from PropBank?

- Provides more structuring of noun phrases & prepositional phrases, intra-sentential coreference and discourse relations
- Collapses more ways of saying the same thing, making much more use of PropBank predicates.
- Provides an interpretation for negation and modality; PropBank just marks them.
How is it really different from PropBank?

Metonymy

- Introduction of understood, but not explicitly mentioned concepts:

  *Gas could go to $10 a gallon*

  (p / possible
   :domain (g / go.01
       :ARG1 (t / thing
           :ARG2-of (p2 / price-01
               :ARG1 (g4 / gas
                   :quant (v2 / volume-quantity
                       :unit (g5 / gallon
                           :quant 1))))
               :ARG4 (m2 / monetary-quantity
                   :unit (d2 / dollar
                       :quant 10))))

When to do it?
PropBank Today – synching w/ AMR

- More flexible coverage
- Noun annotation (re-merging NomBank frames)
  - Eventive nouns: *destruction, escape*
  - Stative nouns: *fault, love*
  - NOT relational nouns
- Adjectives
  - *Comfortable, valuable*
Semantic similarity challenges

- **Etymologically related terms are aliased, same representation**
  - destruction/destroy
- **What if they aren’t etymologically related?**
  - fear.v/fear.n/afraid.adj
  - travel/take a trip
  - desire/want
- **Automatic clustering?**
Light Verb Constructions- differs

- Similarly to PropBank, AMR isn’t confounded by syntactic idiosyncrasies, function words, and light verb constructions.
  
  - PB (“issue a warning”)
    - issue $\rightarrow$ issue.lv
    - warning $\rightarrow$ warn.01,
    - final REL= issue_warning,
      - with warn.01 arguments
  
  - AMR (“issue a warning” $\rightarrow$ warn-01)
Issues: Distinguishing LVCs from heavy usages

Several verbs seem to participate in complex predication but contribute at varying levels to semantics:

- light: produce an alteration ‘alter’
- light: issue a complaint ‘complain’
- heavy: register a complaint

So what about sense distinctions?
We serve food to men.
We serve our community.

Serve —IndirectObject→ men

Sense Distinctions?

We serve organic food.
We serve coffee to connoisseurs.

Serve —DirectObject→ men
Sense Distinctions AMR makes

- call.02 He calls me every day at 8am and 5pm.
- call.03 Secretary of State Baker, in a foreign policy speech, called for the reunification of Germany.

- AMR makes the same distinctions PropBank makes.
Trickier distinctions…

- **take-vpc-v**
  - take.11: *obtain* (“take out a pencil, take out an ad”)
  - **take.26: project anger** (“take it out on her”)
  - take.27: *kill* (“take out the enemy”)
  - take.28: *vacation* (“take out a year”)

- *take* has 256 multi-word expressions
39 more MWE’s for “take”

- TAKE A CHILL
- TAKE A HIT
- TAKE A POWDER
- TAKE ABACK
- TAKE ADVANTAGE
- TAKE AFTER
- TAKE BACK
- TAKE CARE
- TAKE DOWN
- TAKE FOR GRANTED
- TAKE HOME
- TAKE IN VAIN
- TAKE IN CHARGE
- TAKE ISSUE
- TAKE IT EASY
- TAKE ITS/HIS/HER TOLL
SEMLINK

- Extended VerbNet: 6,340 senses
  - 92% PB tokens (8114 verb senses/12,646 all)
- Type-type mapping
  - PB/VN, VN/FN, VN/WN, VN/ON (groupings of WN senses)
- Semi-automatic mapping of WSJ PropBank instances to VerbNet classes and thematic roles, hand-corrected. *(now FrameNet also)*
- VerbNet class tagging as automatic WSD

*Brown, Dligach, Palmer, IWCS 2011; Croce, et. al., ACL2012*
Accuracy & Agreement

- AMR uses the *smatch* metric to calculate agreement rates against consensus AMR annotations
- 4 annotators provided AMRs for all 180 adjudicated sentences (100 *wsj*, 80 *webtext*)
- average *smatch* agreement rates with consensus AMRs were 0.83 (*wsj*) and 0.73 (*webtext*)
- PB IAA generally between 92-98%
Summarizing

- A more abstract labeled dependency tree
  - w/out function words
  - many nouns/adjectives have predicate-argument structures as well as verbs
  - wikified NE’s
  - abstract discourse relations
  - interpretation of modality and negation
  - “some” implicit arguments/relations
  - AND equivalence relations for coreference – makes it a graph.
Challenges AMR doesn’t address

- Sense distinctions
- Semantic similarity
- Metaphors and world knowledge
- Constructions
- New usages
- Coercion, metonymy, implicit arguments, …
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Metaphors

- His cigarette ash fell on the diva’s skirt.
- The curtain fell on the diva.
- By the time the Iron Curtain fell in 1989, differences ran deep indeed.
Jena Hwang – Adapting to New Usages: Incorporating Constructions into VerbNet

- Why constructions?

  “They threw him out of the university”
  Ellos le echaron fuera de la universidad.

- They *threw* him out of the university.
- They *hissed* him out of the university.

  “They whistled to him outside the university”
  Le silbó fuera de la universidad.
New usages

- Not all yarn frogs easily.
amr.isi.edu

- LDC release – 13K
  [http://amr.isi.edu/download.html](http://amr.isi.edu/download.html)

- Publications
  - Pourdamghani, N, Yang Gao, Ulf Hermjakob and Kevin Knight, Aligning English Strings with AMR Graphs, EMNLP 2014
  - Flanigan, J., S. Thomson, J. Carbonell, C, A Discriminative Graph-Based Parser for the Abstract Meaning Representation, ACL 2014
So what about Machine Translation?

- JHU NSF Fred Jelinek Memorial Workshop
  - July, 2014, 4 weeks, Charles University, Prague, the Czech Republic
Aligning parallel corpora

- Subtrees of dependency parses of parallel English/Chinese corpora only have isomorphic matches about 30% of the time.
  - Yuan Ding, Thesis, 2005
- Parallel PropBank structures match almost 60%.
  - Wu & Palmer, SSST, 2011
- What about AMR’s? Will they align even more?
  - Xue, Bojar, Hajič, Palmer, Urešová, Zhang, Not an Interlingua, but Close: Comparison of English AMRs to Chinese and Czech LREC 2014
Semantic Mapping

- Mapping predicate-arguments between languages

Construction has activated the main materials flow in the great southwest.
Prague CL-AMR workshop: Preparatory Efforts

- English, Chinese, and Czech AMR’s of the same 100 sentences and their translations.
- A preliminary mapping from TR to AMR.
- Given a 1M word WSJ English corpus with parallel Czech translations, both in TR
  - And automatically produced AMR’s (from OntoNotes, thanks to Ulf Hermjakob) for the same data
Differences in Lexicalization and Annotation Choice

This is a major "D'oh!" moment.

This is a major "D'oh!" moment.
Annotation Choice Differences

Annotation choice

- To reify or not to reify?

Chinese: reifies “be_temporally_located_at”

English drops “be” and puts “this” as the :domain of “moment”:

- (m / moment
  :mod (m2 / major)
  :domain (t / this)
  :mod (d / d'oh :mode expressive))
Alternative Annotation Choices for English

- English could just as easily reify “is moment” as `temporal_location.01`
  - `(t / temporal_location.01`
    - :Arg1 (t2 / this)
    - :mod (m / major)
    - :mod (d / d'oh :mode expressive))

- Closer match for English and Chinese
- How often is this the case?
Lexicalization differences

- Language specific lexicalization differences
  - Simply different word choices
    - “major” vs. 叫/cry
  - Often a single lexical item in one language is a multi-word expression elsewhere, w/ structure
    - “tells the tale” vs. popsány..
      - (t / tell.01 (p / popsat.1 :Arg1 (t2 / tale) (no :Arg1))
    - “překračovat povolenou rychlost” vs. “speeding”

- Should AMR make more of an effort to treat MWE’s as single lexical items?
Questions to investigate

- Deterministically produce variations for annotation choices = sets of semantically equivalent AMRs ➔ better matches?
- Resources for language-specific alternative lexicalizations, both manual and automatic?
- How much should AMR abstract away from Multi-word expressions?
- When to reify? And when not?
- Etc.,
Prague Workshop: MT with AMRs
Renduchintala and Flanigan
## Results

<table>
<thead>
<tr>
<th>Alignment Scheme</th>
<th>Precision</th>
<th>Recall</th>
<th>F-score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full sentence</td>
<td>0.261</td>
<td>0.363</td>
<td>0.303</td>
</tr>
<tr>
<td>Serialized concepts</td>
<td>0.155</td>
<td>0.290</td>
<td>0.202</td>
</tr>
</tbody>
</table>
Future directions for AMR

- Inter-sentential coreference and discourse relations
- Integrating this with RED (Richer Event Descriptions)
  - Temporal and causal relations between events
- ????
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