

## Natural Logic (NLog) & EL/EPiLOG

NLog: Enables some obvious lexical inferences to be made easily from parsed, ±annotated NL

Two main ideas:

1. Replace terms by more general ones in positive (upward entailing) phrasal contexts, and by more specific ones in negative (downward entailing) ones. So, inference is "polarity-based".

e.g., All dogs bark → All poodles make noises  
 -ve +ve → -ve +ve  
 specialize generalize

e.g., When it rains, the basement gets flooded  
 -ve +ve +ve  
 → When it pours, something gets wet

e.g., The Moon is made of rock, not cheese  
 +ve -ve  
 The Moon is made of minerals, not Cabrales blue cheese

2. Infer the (positive or negated) complement of implicative & presuppositional verbs

e.g., Ed managed to graduate → Ed graduated

e.g., Ed failed to graduate → Ed did not graduate

e.g., Ed knows he is lazy → Ed is lazy

## Combining these methods

e.g., Ed managed to buy a truck  
 +implic. +ve +ve  
 → Ed acquired a vehicle

e.g., (from MacCartney & Manning, 2009)

Jimmy Dean refused to move without his blue jeans  
 +ve -implic. -ve -ve entail. -ve & -ve = +ve  
James Dean did not dance without pants

## Episodic Logic (EL) & the EPiLOG inference engine

EL is an extension of FOL to cover modification and reification of predicates & sentences, and to allow association of episodes with arbitrary sentences.

e.g., Ed knows that he is very lazy → (approximately)

( $\exists e$ : [e at-about Now34] *WordNet-based disambiguation*)

[[Ed knows.s.v (that [Ed (very lazy)])]] \* e]

Skolemize

Axiom: ( $\forall x$  ( $\forall e$  ( $\forall p$ : [[x knows.v p] \* e] "characterizes"  
 [[x believes.v p] \* e] & [p True]]))

[[Ed knows.v (that [Ed (very lazy)])]] \* **E3**  
 +ve presupp.

[[Ed believes.v (that [Ed (very lazy)])]] \* **E3**

(partially describes

EL also allows schemas (containing syntactic metavariables)

$$(\forall_{\text{wff}} w \ [(\text{that } w) \text{ True}] \Leftrightarrow w)$$

← substitute any wff for w

$$(\forall_{\text{pred}} P \ (\forall_{\text{term}} t \ [[t(\text{very } P)] \Rightarrow [t P]]))$$

Thus, being very lazy implies being lazy

So we can derive

[Ed lazy] ("lazy" construed as an enduring, nonepisodic property)

In general, EL (implemented in the EPIDOR engine) uses

- generalized polarity-based\* forward & backward inference (of resolution, w/o conversion to clauses)

forward:  $\frac{\text{MAJ}^-(\varphi), \text{MIN}^+(\varphi')}{\text{MAJ}_\sigma^-(\neg(\text{MIN}_\sigma^+(\perp)))}$       $\sigma$  unifies  $\varphi, \varphi'$

e.g.,  $\neg \text{Dog}(x) \vee \text{Pet}(x), \text{Dog}(\text{Fifi}) \vee \text{Cat}(\text{Fifi})$       $\sigma = (x/\text{Fifi})$

actually,  $(\forall x: [\text{is dog}] [\text{is pet}])$

$\neg(\neg(\perp \vee \text{Cat}(\text{Fifi}))) \vee \text{Pet}(\text{Fifi}) \equiv \text{Cat}(\text{Fifi}) \vee \text{Pet}(\text{Fifi})$  as for resolution

- Some natural deduction rules:
  - assumption of antecedent in proving  $[\varphi \Rightarrow \psi]$
  - assumption of false disjunct in proving  $[\varphi \vee \psi]$
  - some others
- Specialists (e.g., for taxonomies, parts, times, arithmetic, ...) to accelerate inference.