NLP

Introduction to NLP

Representing and Understanding Meaning

Understanding Meaning

- If an agent hears a sentence and can act accordingly, the agent is said to understand it
- Example
  - Leave the book on the table
- Understanding may involve inference
  - Maybe the book is wrapped in paper?
- And pragmatics
  - Which book? Which table?
- So, understanding may involve a procedure

Properties

- Verifiability
  - Can a statement be verified against a knowledge base (KB)
  - Example: does my cat Martin have whiskers?
- Unambiguousness
  - Give me the book
  - Which book?
- Canonical form
- Expressiveness
  - Can the formalism express temporal relations, beliefs, …?
  - Is it domain-independent?
- Inference

Representing Meaning

- One traditional approach is to use logic representations, e.g., FOL (first order logic)
- One can then use theorem proving (inference) to determine whether one statement entails another

Syntax of Propositional Logic

- The simplest type of logic
- The proposition symbols P_1, P_2, … are sentences
  - If S is a sentence, $\neg S$ is a sentence (negation)
  - If S_1 and S_2 are sentences, $S_1 \wedge S_2$ is a sentence (conjunction)
  - If S_1 and S_2 are sentences, $S_1 \vee S_2$ is a sentence (disjunction)
  - If S_1 and S_2 are sentences, $S_1 \Rightarrow S_2$ is a sentence (implication)
  - If S_1 and S_2 are sentences, $S_1 \Leftrightarrow S_2$ is a sentence (biconditional)

Propositional Logic in Backus Naur Form

- Sentence → AtomicSentence | ComplexSentence
- AtomicSentence → True | False | S | T | U ...
- ComplexSentence → (Sentence)

  | ¬Sentence

  | Sentence ∧ Sentence

  | Sentence ∨ Sentence

  | Sentence ⇒ Sentence

  | Sentence ⇔ Sentence

Operator Precedence

$\neg$ (highest)

$\wedge$

$\vee$

$\Rightarrow$

$\Leftrightarrow$ (lowest)

Translating Propositions to English

- A = Today is a holiday.
- B = We are going to the park.

- $A \Rightarrow B$
- $A \land \neg B$
- $\neg A \Rightarrow B$
- $\neg B \Rightarrow A$
- $B \Rightarrow A$

Translating Propositions to English

- A = Today is a holiday.
- B = We are going to the park.

- $A \Rightarrow B$
  If today is a holiday, we are going to the park.
- $A \land \neg B$
  Today is a holiday and we are not going to the park.
- $\neg A \Rightarrow \neg B$
  If today is not a holiday, then we are not going to the park.
- $\neg B \Rightarrow \neg A$
  If we are not going to the park, then today is not a holiday.
- $B \Rightarrow A$
  If we are going to the park, then today is a holiday.

Semantics of Propositional Logic

- $\neg S$ is true iff S is false
- $S_1 \wedge S_2$ is true iff S_1 is true and S_2 is true
- $S_1 \vee S_2$ is true iff S_1 is true or S_2 is true
- $S_1 \Rightarrow S_2$ is true iff S_1 is false or S_2 is true
- i.e., is false iff S_1 is true and S_2 is false
- $S_1 \Leftrightarrow S_2$ is true iff $S_1 \Rightarrow S_2$ is true and $S_2 \Rightarrow S_1$ is true
- Recursively, one can compute the truth value of longer formulas

Connectives

P	Q	¬P	P∧Q	P∨Q	P⇒Q	P⇔Q
F	F	T	F	F	T	T
F	T	T	F	T	T	F
T	F	F	F	T	F	F
T	T	F	T	T	T	T

Logical Equivalence

$(\alpha \wedge \beta)$	$\equiv$	$(\beta \wedge \alpha)$	commutativity of $\wedge$
$(\alpha \vee \beta)$	$\equiv$	$(\beta \vee \alpha)$	commutativity of $\vee$
$((\alpha \wedge \beta) \wedge \gamma)$	$\equiv$	$(\alpha \wedge (\beta \wedge \gamma))$	associativity of $\wedge$
$((\alpha \vee \beta) \vee \gamma)$	$\equiv$	$(\alpha \vee (\beta \vee \gamma))$	associativity of $\vee$
$\neg(\neg\alpha)$	$\equiv$	α	double-negation elimination
$(\alpha \Rightarrow \beta)$	$\equiv$	$(\neg\beta \Rightarrow \neg\alpha)$	contraposition
$(\alpha \Rightarrow \beta)$	$\equiv$	$(\neg\alpha \vee \beta)$	implication elimination
$(\alpha \Leftrightarrow \beta)$	$\equiv$	$((\alpha \Rightarrow \beta) \wedge (\beta \Rightarrow \alpha))$	biconditional elimination
$\neg(\alpha \wedge \beta)$	$\equiv$	$(\neg\alpha \vee \neg\beta)$	de Morgan
$\neg(\alpha \vee \beta)$	$\equiv$	$(\neg\alpha \wedge \neg\beta)$	de Morgan
$(\alpha \wedge (\beta \vee \gamma))$	$\equiv$	$((\alpha \wedge \beta) \vee (\alpha \wedge \gamma))$	distributivity of $\wedge$ over $\vee$
$(\alpha \vee (\beta \wedge \gamma))$	$\equiv$	$((\alpha \vee \beta) \wedge (\alpha \vee \gamma))$	distributivity of $\vee$ over $\wedge$

NLP