LING 438/538
Computational Linguistics

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Student Lecture: 11/29
First Order Predicate Calculus
Representing Meaning

• Many ways to represent a sentence
  – Phonological, morphological, and syntactic
• Need for a formal representation of semantic meaning
  – Representation should be an expression of verifiable facts
    • Verifiability: Ability to compare a statement to a database of known facts
First Order Predicate Calculus (FOPC): The Basics

• Constant: A | B | Burgers | John | ...
• Variable: x | y | z | ...
• Predicate: Serves | Owns | Near | ...
• Function: LocationOf | CuisineOf | ...
• Connectives: $A \lor B | A \land B | A \Rightarrow B$
• Quantifiers: $\forall | \exists$
FOPC: Easy Example

• Mark drives a Saturn.
  – Constants: Mark, Saturn
  – Predicate: drives
  – drives( Mark, Saturn )

• Does the following question yield the same FOPC expression?
  – Does Mark drive a Saturn?
  – The constants and predicate remain the same.
  – A question is a request for verification.
FOPC: Connectives and Negation

• Need to represent connected statements.
• Mark drives a Saturn, not a Honda.
  – Constants: Mark, Saturn, Honda
  – Predicates: drives
  – \( \text{drives}(\text{Mark}, \text{Saturn}) \land \neg \text{drives}(\text{Mark}, \text{Honda}) \)
• In this way we can connect a statement with logical “and” and “or” operators.
FOPC: Variables and Quantifiers

• Variables can represent anonymous objects or all objects of a set.

• Is there a restaurant that serves Greek food near campus?

$$\exists x \text{Restaurant}(x) \land \text{Serves}(x, \text{Greek}) \land \text{Near}(\text{LocOf}(x), \text{LocOf}(\text{Campus}))$$

• We must find an $$x$$ to satisfy the sentence for it to be true.

$$\text{Restaurant}(\text{Jims}) \land \text{Serves}(\text{Jims}, \text{Greek}) \land \text{Near}(\text{LocOf}(\text{Jims}), \text{LocOf}(\text{Campus}))$$
FOPC: If A then B

• All Greek restaurants serve baklava.
  – The word “All” indicates the quantifier to use.
  – This sentence has a “If A then B” meaning.
  \( \forall x \text{ GreekRestaurant}(x) \Rightarrow \text{Serves}(x, \text{Baklava}) \)

• If “A” is true, then “B” must also be true for the statement to be true.
FOPC: Modus Ponens

• Systematically add new knowledge using inference

\[
\begin{align*}
A \\
A \rightarrow B \\
\hline
B
\end{align*}
\]

• A practical example

\[
\begin{align*}
&\text{GreekRestaurant}(Jims) \\
&\forall x \text{GreekRestaurant}(x) \Rightarrow \text{Serves}(x, \text{Greek}) \\
&\hline
&\text{Serves}(Jims, \text{Greek})
\end{align*}
\]
FOPC and Prolog

• FOPC and Prolog are very similar.
  – Prolog loads a database of facts.
  – Prolog tries to verify statements with variables and constants against the database.

• Prolog is a computer recognizable implementation of FOPC with inference.

• Human intervention is still necessary to translate sentences into FOPC or Prolog.