Data and Knowledge Representation
Lecture 1
My Research

- Semantic Knowledge-based System
  - Information retrieval
  - Information integration/presentation
- Consumer Information Retrieval
- Flow Cytometry-based Proteomics
- Share Pathology Information Network
What I Intend to Cover

- Logic
- Medical Ontology
Main Textbook

- Knowledge Representation: Logical, Philosophical, and Computational Foundations
  by John F. Sowa
Motivation

- Representing data and knowledge for computing
  - Develop
  - Maintain
  - Share
Medical Data and Knowledge

- Large variety
- Many possible representations
- Implication of representation on computing
Example of Medical Data

This is a 51-year-old female admitted through the emergency room with syncopal episode with chest pain and also noted to have epigastric discomfort. The patient was admitted and started on Lovenox and nitroglycerin paste. The patient had serial cardiac enzymes and ruled out for myocardial infarction. The patient underwent a dual isotope stress test. There was no evidence of reversible ischemia on the Cardiolite scan. The patient has been ambulated. The patient had a Holter monitor placed but the report is not available at this time. The patient has remained hemodynamically stable. Will discharge.

http://www.angelfire.com/mt/nashrose/dsch.html
Examples of Medical Knowledge

- Nitrates are a safe and effective treatment that can be used in patients with angina and left ventricular systolic dysfunction.
- On the basis of currently published evidence, amlodipine is the calcium channel antagonist that it is safest to use in patients with heart failure and left ventricular systolic dysfunction.
- Coronary artery bypass grafting may be indicated, in some, for relief of angina.
- All patients with heart failure and angina should be referred for specialist assessment.
- Patients with angina and mild to moderately symptomatically severe heart failure that is well controlled, and who have no other contraindications to major surgery, should be considered for coronary artery bypass grafting on prognostic (as well as symptomatic) grounds.
Challenge

- Philosophical difference
- Domain difference
- Application difference
- Developer difference
- Liability
- Cost
Formalism and Conceptualization

- Natural Language is the most expressive form of formalism and conceptualization.
- Conceptualization is an abstract and simplified view of the world.
- Such simplification allow computer and human alike to communicate in an unambiguous fashion (e.g. “and” vs. “&”).
Logic

- A tool for reasoning
- Provide basic concepts used in many computer science fields (AI, IR, DB, etc.)
- Used in many informatics applications
Propositional Logic

- Proposition
- Basic operators
- Language
- Truth table
- Boolean Algebra
A proposition is a symbolic variable whose value must be either True or False, and which stands for a natural language statement which could be either true or false.

Examples:
- A = Smith has chest pain
- B = Smith is depressed
- C = It is raining
Operators

- Logic And
- Inclusive Or
- Exclusive Or
- Logic Not
- Logical Implication
- Logical Equivalence
## Logical And $\land$

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>$A \land B$</th>
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<tbody>
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# Inclusive Logical Or (V)

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# Exclusive Logical Or (\(\otimes\))

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<th>A</th>
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<th>A (\otimes) B</th>
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Inclusive vs. Exclusive

- Natural language “Or” can mean either
- Exclusive not often used (except in circuit design)
Medical Example

- “Heart AND Lung disease”: does patients have to have both? Or either?
- “Foot AND mouth disease”: what does “AND” mean in this case?
Logical Not ( \( \neg \) )

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<th>A</th>
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### Logical Implication ($\rightarrow$)

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Understanding “→”

- This is an operator. Although we call it “imply” or “implication”, do not try to understand its semantic from the name. We could have called it “I” and still define its semantic the same way.

- A→B “means” A is sufficient, but not necessary to make B true.
  - E.g. Let A be “having cold” and B be “drink water”, A → B can be interpreted as “should drink water” when “having cold”. However, you can drink water even when you don’t have cold. Thus A → B still is true when A is not true.
Logical Equivalence ($\leftrightarrow$)

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<th>A</th>
<th>B</th>
<th>A $\leftrightarrow$ B</th>
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Understanding “→”

- A→B is different from A=B
  - A: a person is pregnant. B: a person is woman.
  - In this case, A→B is true, A=B is not.
- Use formal logic to represent knowledge of the real world, not the other way around.
Well-Formed Formulas

- Formula
  - A term (string) in prepositional logic
- Well-formed formula (WFF)
  - A term that is constructed correctly according to propositional logic syntax rules
WFF

- Constants: \textit{False, True}
- Variables: \textit{P, Q, R}
- If \(a\) is WFF, \(\neg a\) is WFF
- If \(a\) and \(b\) are WFF, \(a \land b\) are WFF
- If \(a\) and \(b\) are WFF, \(a \lor b\) are WFF
- If \(a\) and \(b\) are WFF, \(a \rightarrow b\) are WFF
- If \(a\) and \(b\) are WFF, \(a \leftrightarrow b\) are WFF
- Any formula that cannot be constructed using these rules are not WFF
Precedence of Logical Operators

- \( \neg \)
- \( \land \)
- \( \lor \)
- \( \rightarrow \)
- \( \leftrightarrow \)
Let Try An Example

- Order Test A for all male over 70, smokers with family history of cancer, and women with chronic cough and family history of cancer. Otherwise, do not order it.
  - Male: a person being male
  - Old: a person being over 70
  - Smoker: a person being a smoker
  - Cough: a person having chronic cough
  - FHC: a person having family history of cancer
  - OrderA: Order Test A

\[(\text{Male} \land \text{Old}) \lor (\text{Smoker} \land \text{FHC}) \lor (\neg \text{Male} \land \text{Cough} \land \text{FHC}) \iff \text{OrderA}\]
Examples

- Smokers are those who are currently smoking or had quit smoking for less than 6 months.
- A document is completed only after signed by both the chief resident and the attending physician.
- Smith is depressed whenever it rains.
A Few Comments

- Use parentheses if precedence not clear
- Very similar to programming language operators’ precedence
- Precedence in natural language depend more on context
  - E.g. “no heart and lung disease”
  - E.g. “no family history and healthy life style”
Truth Table

- An easy way to evaluate propositions

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>A ∨ B</th>
<th>¬B</th>
<th>(A ∨ B) ∧ ¬B</th>
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Let Try An Example

- Order Test A for all male over 70, smokers with family history of cancer, and women with chronic cough and family history of cancer. Otherwise, do not order it.

\[(\text{Male} \land \neg \text{Young}) \lor (\text{Smoker} \land \text{FHC}) \lor (\neg \text{Male} \land \text{Cough} \land \text{FHC}) \iff \text{Order A}\]

<table>
<thead>
<tr>
<th>Male</th>
<th>Young(&lt;=70)</th>
<th>Smoker</th>
<th>FHC</th>
<th>Cough</th>
<th>Order Test A</th>
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Tautology and Contradiction

- Male ∨ ¬Male
- Tautology: proposition that is always true
- Healthy ∧ ¬Healthy
- Contradiction: proposition that is always false
Extra Reading

- Aho’s book chapter 12
- Sowa’s book p1-39