Homework III

Please be complete as possible! Show me what you can do! Due October 20, 2009 at the beginning of class.

1. Without appealing to the OED (LOL or simply recapitulating notes from class) please define
   (a) *inference*
   (b) *logic*
   (c) *machine learning*
   (d) *informatics*
   (e) *truth*
2. You've now read two books on problem solving. What did you learn from *The Man Who Mistook His Wife for a Hat*? Compare this to what you learned from *Blink!*. One of Informatics' more important goal is to make thinking devices. What are your thoughts, so far, in achieving this goal?
3. Complete the following sentences.
   (a) An environment σ is . . ..
   (b) . . . is a sentence that is true for all environments.
   (c) If, for a statement $\mathcal{S}$, $\exists\,\sigma \vdash_\sigma \mathcal{S} \wedge \exists\,\sigma \vdash_\sigma \neg\,\mathcal{S}$, then the statement is called . . .
   (d) A statement $\mathcal{S}$ is statisfiable if . . .
   (e) If, for a statment $\mathcal{S}$, $\forall\,\sigma \vdash_\sigma \neg\,\mathcal{S}$, the $\mathcal{S}$ is . . .
4. Write a 30 word abstract of the article given to you in class. Write a 15 word abstract. Summarization is one of the most critical and difficult processes to automate Informatics. One research problem I personally am working on is better understanding the biomolecular nature of diseases; hundreds of thousands of research papers exist and thousands are added every day. Imagine how much information is contained in this growing corpus! But we're at an impasse: given a particular disease X, we'd like to gather and *logically* assemble all the information pertinent to X. There is simply no way to do this *without* creating an *automated* system. This problem is universal–no less important to other areas of study–like business, art, sports.
   (a) Discuss how a person abstracts an article.
   (b) My approach to the problem was to first use TFIDF on the entire corpus, then using terms from user, create a small ontology of terms that were unlikely to occur by random (log odds). The process was then iterated until the user was satisfied with the results. How would you tackle the problem–don't worry about programming or being overly technical. Simply explain at a high-level, what you might do to solve this problem.
   (c) How would you *test* this system?
   (d) From the perspective of a user, what would be some concerns you must address
   (e) Why did I ask for a 30 word abstract, then a 15 word abstract?
   (f) Define **TFIDF**
5. Identify the following English sentences suitable for our propositional logic
   (a) "Three is greater than four."
   (b) "Jennie draws dinosaurs."
   (c) "All unmarried men are bachelors."
   (d) "I love my H101 class."
   (e) "$x \geq 1$."

(f) "$\exists\, x$ (x is a natural number) $\wedge\, x \geq 3$"

6. Consider $C, A \rightarrow B, \neg B \rightarrow C \vdash A$.

   (a) What does it mean that say whether this argument is valid or invalid?

   (b) Use a truth table to establish its validity.

   (c) Use a proof tree to establish its validity.

   (d) Another means to establish validity is called *refutation*. It is really no different from the proof tree; when a statement is refuted, it's shown to be False. The algorithm is:

   INPUT $A_1, A_2, \ldots, A_n, C$
   OUTPUT True or False

   Step
   (0) Form $A_1 \wedge A_2 \wedge \ldots, A_n \wedge \neg C$
   (1) Push $\neg$ inward to terms–commas represent $\wedge$
   (2) Combine different conjunctive clauses until either nothing new is formed or True or False is found

   Here's is an example in using refutation to check the validity of $A \rightarrow B, B \rightarrow C, C \rightarrow D \vdash A \rightarrow D$

$$\{A \rightarrow B, B \rightarrow C, C \rightarrow D, \neg(A \rightarrow D)\} \quad (1)$$
$$\{(\neg A \vee B), (\neg B \vee C), (\neg C \vee D), A, \neg D\} \quad (2)$$
$$\{A \wedge (\neg A \vee B), (\neg B \vee C), (\neg C \vee D), A, \neg D\} \quad (3)$$
$$\{(false \vee A, B), (\neg B \vee C), (\neg C \vee D), A, \neg D\} \quad (4)$$
$$\{B, (\neg B \vee C), (\neg C \vee D), A, \neg D\} \quad (5)$$
$$\{B, (false \vee B, C), (\neg C \vee D), A, \neg D\} \quad (6)$$
$$\{B, C, (\neg C \vee D), A, \neg D\} \quad (7)$$
$$\{B, C, (false \vee C, D), A, \neg D\} \quad (8)$$
$$\{B, C, D, A, \neg D\} \quad (9)$$
$$\{B, C, A, D \wedge \neg D\} \rightarrow false \quad (10)$$

   In Step 3, I've *distributed* A over $(\neg A \vee B)$. You already have seen this rule: $3(2+5) = 3(2)+3(5) = 6 + 15 = 21$. In Step 4 $(A \wedge \neg A) \vee (A \wedge B) \leftrightarrow false \vee (A \wedge B) \leftrightarrow A, B$ because we know, for any statement $\mathcal{S}$, $\mathcal{S} \vee false \leftrightarrow \mathcal{S}$. You can prove this to yourself using a truth table:

$\mathcal{S}$	$\mathcal{S} \vee false \leftrightarrow \mathcal{S}$	
$true$	$(true \vee false) \leftrightarrow true$	$true$
$false$	$(falseveefalse) \leftrightarrow false$	$true$

   So, for any statement $\mathcal{S}$, $\mathcal{S} \vee false \leftrightarrow \mathcal{S}$ is a tautology. In Step 10 D and it's negation form $false$. For any statement $\mathcal{S}$, $\mathcal{S} \wedge false \leftrightarrow false$ (this is a tautology too). Since we've found a contradiction (refutation), it must be that the original argument was valid. For this problem, use refutation to see if $P \rightarrow Q, \neg Q \rightarrow R, R \vdash P$.

7. (Adapted from Giarratano and Riley) You are hired by Toyota Automotive to help with their vehicle diagnostic system–the system is an attempt to let the vehicle diagnose itself. Let the following variables stand for the declarative sentences (presume we know *which* vehicle *etc.*:

B	"The battery is good."
E	"The electrical charge is present."
G	"The vehicle has fuel."
C	"The vehicle is operational."
F	"The sparkplugs will fire."
R	"The engine will work."
T	"The tires are not flat."

Translate the following sentences:

(a) $B \wedge S \wedge G \wedge T \rightarrow C$

(b) $B \rightarrow E$

(c) $E \wedge S \rightarrow F$ ($\wedge$ before $\rightarrow$)

(d) $F \wedge G \rightarrow R$

(e) $R \wedge T \rightarrow C$

Prove that if sentences (b),(c),(d),(e) are `True`, then sentence (a) is `True`. Create a circuit for the conjunction of (b),(c),(d),(e). Extra-credit if you use refutation for proof.

8. Give *two* primary challenges in using formal logic as means of representing inferencing.