CSCE476/876 **Fall 2019**

Homework 7

Assigned on: Friday, November 1^{st}, 2019.

Due: Friday, November 15^{th}, 2019.

Points: 100, plus a potential 20 bonus points in the main tract. Additionally, you have the option of implementing a SAT solver for 100 additional bonus points.

Contents

Alert: If you submit your homework handwritten, it must be *absolutely neat* or it *will not* be corrected. If you type your homework (preferable), submit using webhandin.

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1 AIMA, Exercise 7.1, page 279. (16 points)

2 AIMA, Exercise 7.7, page 281. (6 points)

3 Truth Tables (8 points)

Use truth tables to show that each of the following is a tautology.

1. $(p \land q) \rightarrow \neg(\neg p \lor \neg q)$
2. $[Mary \land (Mary \rightarrow Susy)] \rightarrow Susy$
3. $\alpha \rightarrow [\beta \rightarrow (\alpha \land \beta)]$
4. $(a \rightarrow b) \rightarrow [(b \rightarrow c) \rightarrow (a \rightarrow c)]$

4 AIMA, Exercise 7.10, page 281. (16 points)

Only b, c, d, e, f, and g.

5 Logical Equivalences (8 points)

Using a method of your choice, verify:

1. $(\alpha \to \beta) \equiv (\neg\beta \to \neg\alpha)$ contraposition
2. $\neg(\alpha \wedge \beta) \equiv (\neg\alpha \vee \neg\beta)$ de Morgan
3. $(\alpha \wedge (\beta \vee \gamma)) \equiv ((\alpha \wedge \gamma) \vee (\alpha \wedge \beta))$ distributivity of $\wedge$ over $\vee$

6 AIMA, Exercise 7.22, page 284. (18 points + 20 bonus)

Parts a, b, and c are required. Parts d, e, and f are bonus.

7 Proofs (28 points)

Give the explantions of each step if the steps are given, and give both the explanation and step if they are not.

- If $q \wedge (r \wedge p), t \to v, v \to \neg p$, then $\neg t \wedge r$.

Proof	**Explanations**
1. $q \wedge (r \wedge p)$	Given
2. $t \to v$	Given
3. $v \to \neg p$	Given
4. $t \to \neg p$	
5. $(r \wedge p)$	
6. r	
7. p	
8. $\neg\neg p$	
9. $\neg t$	
10. $\neg t \wedge r$	

- If $p \to (q \wedge r), q \to s$, and $r \to t$, then $p \to (s \wedge t)$.

Proof	**Explanations**
1.	
2.	
3.	
4.	
5.	
6.	
7.	

- **Prove by contradiction.**

  If $\neg(\neg p \wedge q), p \to (\neg t \vee r), q$, and t, then r.

Proof	**Explanations**
1. $\neg(\neg p \wedge q)$	Given
2. $p \to (\neg t \vee r)$	Given

3. q Given
4. t Given
5. $\neg r$ Negation of Conclusion
6.
7.
8.
9.
10.
11.
12.

8 Bonus: Implementation, Solving SAT (100 points)

Write a search algorithm to determine the satisfiability of a SAT instance. You can either write:

- A DPLL procedure (backtrack search),
- A local search procedure.

You must

- Clearly describe, in addition to your code, your data structures, how your search algorithm operates, and the improvements, if any, that you have included in your code.
- We recommend that you use the standard file for input files known as the 'simplified version of the DIMACS format':
  http://www.satcompetition.org/2009/format-benchmarks2009.html
- Test the performance of your algorithm on some non trivial uniform random instances taken from the SAT Competition. For example:
  http://www.cs.ubc.ca/~hoos/SATLIB/benchm.html

Alert: many implementations exist in the literature and on the web. We expect you to do your *own* implementation.