Homework 7


Due: Friday, April 3, 2009.

You can choose to do either Section 1 (worth 110 points) or Sections 2 to 9 (with 110 points plus 20 bonus points). It is your decision. If you choose to do both options, you will receive the maximum of the grades of the two sections, not the sum.

1 Implementation: Solving SAT 110 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.

2 AIMA, Exercise 6.3, page 190. 10 points

3 AIMA, Exercise 7.2, page 236. 16 points

4 AIMA, Exercise 7.5, page 237. 6 points

Note that $A \iff B \iff C$ is equivalent to $A \iff B$ and $B \iff C$. 
5 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. \((a \rightarrow b) \rightarrow [(b \rightarrow c) \rightarrow (a \rightarrow c)]\)

6 AIMA, Exercise 7.8, page 237. 16 points

only c, d, e, f, g and h.

7 Logical Equivalences 8 points

Using a method of your choice, verify:

1. \((\alpha \rightarrow \beta) \equiv (\neg \beta \rightarrow \neg \alpha)\) contraposition
2. \(\neg(\alpha \land \beta) \equiv (\neg \alpha \lor \neg \beta)\) de Morgan
3. \((\alpha \land (\beta \lor \gamma)) \equiv ((\alpha \land \gamma) \lor (\alpha \land \beta))\) distributivity of \(\land\) over \(\lor\)

8 Proofs 28 points

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

• If \(q \land (r \land p), t \rightarrow v, v \rightarrow \neg p, \) then \(\neg t \land r\).

Proof

1. \(q \land (r \land p)\)  Given
2. \(t \rightarrow v\)  Given
3. \(v \rightarrow \neg p\)  Given
4. \(t \rightarrow \neg p\)  Given
5. \((r \land p)\)  Given
6. \(r\)  Given
7. \(p\)  Given
8. \(\neg \neg p\)  Given
9. \(\neg t\)  Given
10. \( \neg t \land r \)

- If \( p \rightarrow (q \land r) \), \( q \rightarrow s \), and \( r \rightarrow t \), then \( p \rightarrow (s \land t) \).

Proof

1.
2.
3.
4.
5.
6.
7.

Explanations
• Prove by contradiction.
If \( \neg(\neg p \land q), p \to (\neg t \lor r), q, \) and \( t, \) then \( r. \)

Proof

1. \( \neg(\neg p \land q) \)
2. \( p \to (\neg t \lor r) \)
3. \( q \)
4. \( t \)
5. \( \neg r \)

Explanations
Given
Given
Given
Given
Negation of Conclusion

9  **AIMA, Exercise 7.11, page 238.**  
18 points + 20 bonus

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