CS 730/830: Intro AI

asst 5 is posted

EOLQs

Introduction to Knowledge Representation and Reasoning

What is Knowledge Representation?

- Representing facts
- Reasoning with facts

Can computers be meaningful?

History of Logic

Philo of Megara (5C BC): truth tables
Aristotle (322BC): tautologies of proper arguments
Gottfried Leibniz (1646-1716): inference as math-like (bogus) logic
George Boole (1854): *The Laws of Thought* (almost propositional logic)
Gottlob Frege (1879): Conceptual Notation (propositional and first-order logic)
Dartmouth Conference (1956): 'AI' coined
Advice Taker (1959): manifesto for declarative knowledge
CYCorp (1984- , www.cyc.com): slightly more complicated than first-order logic

The Advice Taker (1959)

John McCarthy: "AI", Lisp, time-sharing

Empirical Philosophy = Science

The Physical Symbol System Hypothesis: A physical symbol system has the necessary and sufficient means for general intelligent action. (Newell and Simon)

where a

Symbol is a designating pattern that can be combined with others to form another designating pattern

and

Designation means standing in for something in the world

Propositional Logic

Propositional Logic

$$itisraining$$
$$iamwet$$
$$itisraining \rightarrow iamwet$$

x	y	$x \wedge y$
T	T	T
T	F	F
F	T	F
F	F	F

x	y	$x \rightarrow y$
T	T	T
T	F	F
F	T	T
F	F	T

$$\frac{x \quad x \rightarrow y}{y}$$ modus ponens

$$\wedge, \vee, \neg, \rightarrow (\supset, \Rightarrow), \leftrightarrow$$

Logic

A logic is a formal system:

- syntax: defines sentences
- semantics: relation to world
- inference rules: reaching new conclusions

three layers: proof, models, reality

flexible, general, principled

Encode in Propositional Logic

If the unicorn is mythical, then it is immortal, but if it is not mythical, then it is a mortal mammal. If the unicorn is either immortal or a mammal, then it is horned. The unicorn is magical if it is horned.

Semantics

Interpretation: possible world = state of affairs = truth value for each proposition
Meaning: values across all interpretations
Model of P: an interpretation in which P is true
Satisfiable: $\exists$ a model
Entailment: if α is true in every model of KB, then $KB \models \alpha$
Valid: true in any interpretation

x	y	$(x \wedge \neg y)$	z	$(x \wedge \neg y) \rightarrow z$
T	T	F	T	T
T	T	F	F	T
T	F	T	T	T
T	F	T	F	F
F	T	F	T	T
F	T	F	F	T
F	F	F	T	T
F	F	F	F	T

Break

- asst 4
- asst 5

Reasoning

Propositional Reasoning

Entailment: if β is true in every model of α, then $\alpha \models \beta$

computing entailment
soundness, completeness

$\alpha \models \beta$ iff $\alpha \rightarrow \beta$ is valid

$\alpha \models \beta$ iff $\alpha \wedge \neg\beta$ is unsatisfiable

determining satisfiability is NP-complete
eg, easy to test proof of yes!

Boolean Satisfiability

Given a formula of boolean logic, is there any assignment of T/F to its variables that makes the entire formula true?

$$(a \vee b \vee c) \wedge (\neg a \vee b \vee \neg c) \wedge (\neg a \vee \neg b \vee c) \wedge (\neg a \vee \neg b \vee \neg c)$$

The Davis-Logemann-Loveland Algorithm (1962)

DLL(ϕ):
UnitPropagate(ϕ)
[PureLiterals(ϕ)]
if ϕ is empty, return SAT
if ϕ contains empty clause, return UNSAT
$v \leftarrow$ choose a variable
if DLL(SetVariable(ϕ with v =true))=SAT, return SAT
else, return DLL(SetVariable(ϕ with v =false))

UnitPropagate(ϕ):
as long as there is a unit clause
  SetVariable according to the literal

SetVariable(ϕ with $v = value$):
remove clauses where v appears as $value$
remove v from clauses where it appears as $\neg value$

WalkSAT/SKC (1994)


```
for 1 to maxTries
    assign all variables randomly
    from 1 to maxFlips
        randomly choose an unsatisfied clause c
        if one or more of c's variables can be flipped while
            breaking nothing,
            randomly choose among those
        else
            with probability p
                randomly choose one of c's variables
            else
                randomly choose among those of c's variables that
                minimize breaks
        flip the variable
        if formula satisfied, terminate
```

$p \approx 0.5$?

Local Search for SAT

DPLL: 50 vars = 1.4 secs, 100 vars = 2.8 min, 140 vars = 4.7 hrs

Local Search for SAT

DPLL: 50 vars = 1.4 secs, 100 vars = 2.8 min, 140 vars = 4.7 hrs

GSAT: 100 vars = 6 secs, 140 vars = 14 secs, 500 vars = 1.6 hrs

EOLQs

Please write down the most pressing question you have about the course material covered so far and put it in the box on your way out.

Thanks!