

CSC384:Lecture13

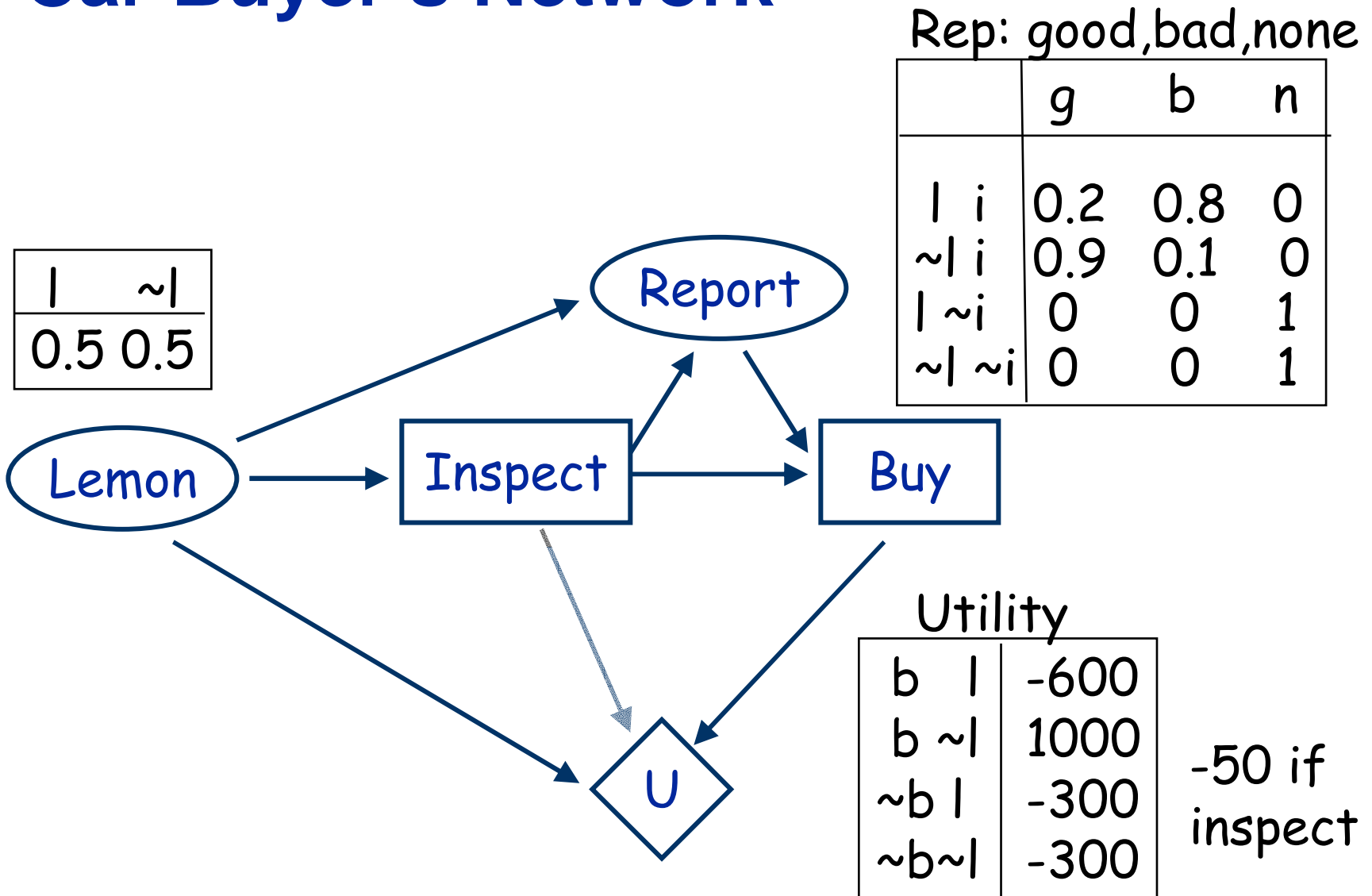
■ Today

- wrapupdecisionnets(incl.slidesfromlastweek)
- coursewrapup
 - whatwe'vecovered
 - whatwehaven't

A Detailed Decision Net Example

- Setting: you want to buy a used car, but there's a good chance it is a "lemon" (i.e., prone to breakdown). Before deciding to buy it, you can take it to a mechanic for inspection. S/he will give you a report on the car, labelling it either "good" or "bad". A good report is positively correlated with the car being sound, while a bad report is positively correlated with the car being a lemon.
- The report costs \$50 however. So you could risk it, and buy the car without the report.
- Owning a sound car is better than having no car, which is better than owning a lemon.

Car Buyer's Network



Evaluate Last Decision: Buy (1)

- $EU(B|I,R) = \sum_L P(L|I,R,B) U(L,B)$
- $I = i, R = g$:
 - $EU(\text{buy}) = P(I|i, g) U(I,\text{buy}) + P(\sim I|i, g) U(\sim I,\text{buy}) - 50$
 $= .18 * -600 + .82 * 1000 - 50 = 662$
 - $EU(\sim \text{buy}) = P(I|i, g) U(I,\sim \text{buy}) + P(\sim I|i, g) U(\sim I,\sim \text{buy}) - 50$
 $= -300 - 50 = -350$ (-300 indep. of lemon)
 - So optimal $\delta_{Buy}(i,g) = \text{buy}$

Evaluate Last Decision: Buy (2)

■ $I = i, R = b$:

- $EU(\text{buy}) = P(I|i, b) U(I, \text{buy}) + P(\sim I|i, b) U(\sim I, \text{buy}) - 50$
 $= .89 * -600 + .11 * 1000 - 50 = -474$
- $EU(\sim \text{buy}) = P(I|i, b) U(I, \sim \text{buy}) + P(\sim I|i, b) U(\sim I, \sim \text{buy}) - 50$
 $= -300 - 50 = -350$ (-300 indep. of lemon)
- So optimal $\delta_{Buy}(i, b) = \sim \text{buy}$

Evaluate Last Decision: Buy (3)

- $I = \sim i$, $R = n$ (note: no inspection cost subtracted)
 - $EU(\text{buy}) = P(I|\sim i, n) U(I, \text{buy}) + P(\sim I|\sim i, n) U(\sim I, \text{buy})$
 $= .5 * -600 + .5 * 1000 = 200$
 - $EU(\sim \text{buy}) = P(I|\sim i, n) U(I, \sim \text{buy}) + P(\sim I|\sim i, n) U(\sim I, \sim \text{buy})$
 $= -300 - 50 = -350$ (-300 indep. of lemon)
 - So optimal $\delta_{Buy}(\sim i, n) = \text{buy}$
- So optimal policy for Buy is:
 - $\delta_{Buy}(i, g) = \text{buy}$; $\delta_{Buy}(i, b) = \sim \text{buy}$; $\delta_{Buy}(\sim i, n) = \text{buy}$
- Note: we don't bother computing policy for $(i, \sim n)$, $(\sim i, g)$, or $(\sim i, b)$, since these occur with probability 0

Evaluate First Decision: Inspect

- $EU(I) = \sum_{L,R} P(L,R|I) U(L, \delta_{Buy}(I,R))$
 - where $P(R,L|I) = P(R|L,I)P(L|I)$
 - $EU(i) = .1 \cdot -600 + .4 \cdot -300 + .45 \cdot 1000 + .05 \cdot -300 - 50$
 $= 237.5 - 50 = 187.5$
 - $EU(\sim i) = P(I|\sim i, n) U(I, buy) + P(\sim I|\sim i, n) U(\sim I, buy)$
 $= .5 \cdot -600 + .5 \cdot 1000 = 200$
 - So optimal $\delta_{Inspect}(\sim i) = buy$



	$P(R,L I)$	δ_{Buy}	$U(L, \delta_{Buy})$
g,I	0.1	buy	$-600 - 50 = -650$
b,I	0.4	~buy	$-300 - 50 = -350$
g,~I	0.45	buy	$1000 - 50 = 950$
b,~I	0.05	~buy	$-300 - 50 = -350$

Value of Information

- So optimal policy is: don't inspect, buy the car
 - $EU = 200$
 - Notice that the EU of inspecting the car, then buying it iff you get a good report, is 237.5 less the cost of the inspection (50). So inspection not worth the improvement in EU.
 - But suppose inspection cost \$25: then it would be worth it ($EU = 237.5 - 25 = 212.5 > EU(\sim i)$)
 - The *expected value of information* associated with inspection is 37.5 (it improves expected utility by this amount ignoring cost of inspection). How? Gives opportunity to change decision (\sim buy if bad).
 - You should be willing to pay up to \$37.5 for the report

What We've Covered

- Logic and knowledge representation
 - logical representations of beliefs
 - uncertainty (lack of knowledge) is **not** quantified
 - DCL, inference procedures for DCL, uses of DCL
- Problem Solving (Search)
 - considered “decision making” in unstructured settings
 - states/actions are primitive (elements of graph)
 - added the interesting complication of an opponent
- Planning
 - essentially the combination of logical KR with search
 - different “search” techniques often appropriate

What We've Covered

- Probabilistic Reasoning and Representation
 - Bayes net representations of beliefs
 - uncertainty (lack of knowledge) **is** quantified
 - DCL, inference procedures for DCL, uses of DCL
- Decision Making under Uncertainty
 - extend the “certain” problem solving techniques (search, planning) to the uncertain case
 - decision trees: analog of unstructured search
 - decision networks: analog of planning

Exam Notes

- Exam will be 2 hours long, 100 points
- Style similar to midterms
- All assigned readings, assignments, and lecture notes will be covered
- I've already posted a brief review sheet of topics and readings on the Web site
- For review: check out Computational Intelligence web site for exam style questions
 - you're probably aware that old exams are available from the A&S web page

What we Didn't Cover

- Within each of the subtopics, there's a lot of really neat stuff we didn't manage to get to
- Logic/KR:
 - alternative representation schemes; full FOL; sophisticated inference schemes (e.g., stochastic local search (SLS) methods)
- Search:
 - advanced search methods (SLS, constraint-based methods, advanced backtracking techniques,...)
 - deep analysis of heuristics, automatic heuristic generation, problem space formulation, ...

What we Didn't Cover

■ Planning

- advanced planning techniques (least-commitment, abstraction, decomposition, conditional, quantified, SATPlan, GraphPlan, approximation, etc...)

■ Bayes Nets

- advanced/alternative inference techniques
- model construction and learning

■ Decision Theory

- more in-depth models (Markov decision processes)
- approximation techniques
- preference elicitation

Other Areas

- Computational Vision
- Robotics
- Computational Linguistics/Speech Recognition
- Machine Learning
- Multiagent Systems/Economic Models

Computational Vision



(a)



(b)



(c)

From J. Russell, J. Friedman, "Image Segmentation in Video Sequences", UCI-90.

Computational Linguistics

Yahoo reports its latest quarter after the close, with analysts calling for a profit of 2 cents a share, up from last year's 1-cent-per-share net income.

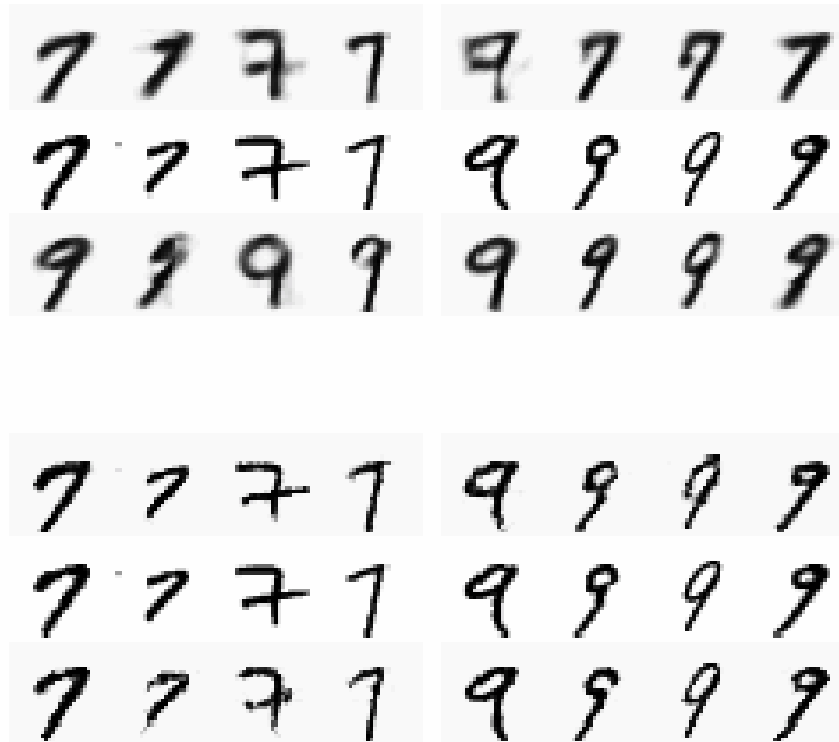
But despite that modest climb for Yahoo, tracking firm Thomson Financial/First Call is calling for a 9 per cent slide in first-quarter profit. The much-anticipated rebound in earnings isn't expected until next quarter, when a rise of about 9 per cent is seen. For the third quarter, Thomson Financial is calling for a 30 per cent rise in profits.

For now, the problem appears to be uncertainty, according to Chuck Hill, the tracking firm's director of research.

"I hate to say it, but lack of visibility is a big problem right now — even more so than in a typical recovery," he said, appearing on ROBTv Wednesday morning.

That lack of visibility sparked a harsh profit warning from blue chip

Machine Learning

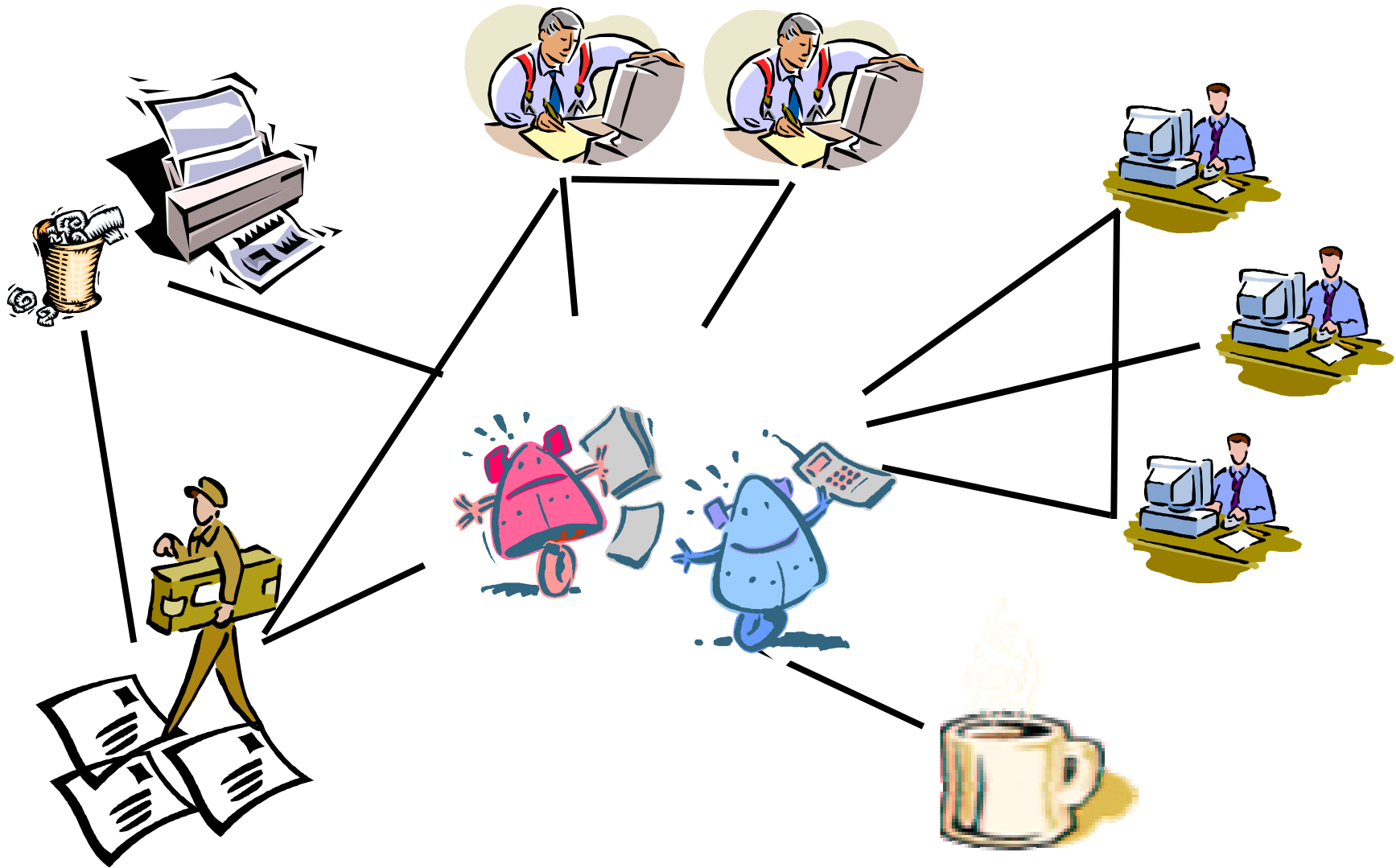


From P. Dayara, P.inton,, "Recognizing and written digits using hierarchical products of experts", IJCV-01.

Machine Learning

- Classification
- Clustering
- Density estimation
- Reinforcement Learning
 - scheduling, cell phone channel allocation, backgammon (TD-Gammon), juggling robots
- many and various techniques

Multiagent Systems



Multiagent Decision Making

- Multiagent decision making presents some unique challenges
 - as in games: the effects and utility of your own actions depends on what other people do
 - we considered a few example **games** earlier
 - recapped in next couple of slides
 - these are games in the formal sense studied in economics and game theory

Game 1: Battlebots

		Red Robot		
		☐offee	☐ea	
Blue Robot	☐offee	0 ☐ 0	8 ☐ 10	red payoff☐blue payoff
	☐ea	10 ☐ 8	0 ☐ 0	

- What should the robots do?
 - both go for coffee?
 - red coffee, blue tea? blue coffee, red tea?
 - what about each choosing coffee or tea randomly?
 - e.g., choose coffee with $p=5/9$, tea with $p=4/9$

Game 2: Matching Pennies

		Red player		
		heads	tails	
Blue player	heads	1 -1	-1 1	red payoff-blue payoff
	tails	-1 1	1 -1	

- What should the players do?
 - if blue plays heads, red wants to play heads
 - if red plays heads, blue wants to play tails
 - if blue plays tails, red wants to play tails
 - if red plays tails, blue wants to play heads...
- What about random choice? 50-50?

Game 3: Prisoner's Dilemma

		Red player		
		operate	defect	
Blue player	operate	3 3	0 0	red payoff blue payoff
	defect	0 1	1 1	

- What should the players do?
 - only “rational” thing to do is for both to defect
 - but both are worse off

Nash Equilibrium

- In games such as these, “rationality” seems to be a “joint venture”
 - looking for pairs (or sets for multi-player games) of strategies that are “stable”
 - i.e., if I play my part of the **strategy profile**, you have no reason not to play your part of it---you will be better off to stick with it
- This is a **Nash equilibrium**

Properties of Equilibria

- Computing equilibria is much harder than just maximizing expected utility
- Difficulties:
 - equilibrium may require randomization (matching pennies)
 - equilibrium may lead to socially undesirable outcomes (prisoner's dilemma)
 - multiple equilibria may exist, so how do we choose? (e.g., Battlebots)
 - many computational challenges
- Cooperative Solutions
- Repeated Games

Applications of Game Theory

- Coordination
- Automated Negotiation
- Automated Bidding and Purchasing in Markets
 - design of markets, auctions, bidding rules, etc.
 - e.g., Vickrey (2nd price) auction
- Allocation of Resources
 - spectrum rights
 - network bandwidth
 - and on and on and on...