CSPs

1 handout: slides

asst 4 posted

EOLQs

CSPs

Constraint Satisfaction Problems

Types of Search Problems

- Shortest-path (vacuum, tile puzzle, M&C)
  - given operators and their costs
  - want least-cost path to a goal
  - sequential decision-making
  - goal depth/cost unknown
- Decisions with an adversary (chess, tic-tac-toe)
  - adversary might prevent path to best goal
  - want best assured outcome
- Constraint satisfaction (map coloring, n-queens)
  - set of unordered decisions
  - any goal is fine
  - fixed depth
  - explicit constraints on partial solutions

Map coloring: Given a map of n countries and a set of k colors, color every country differently from its neighbors.

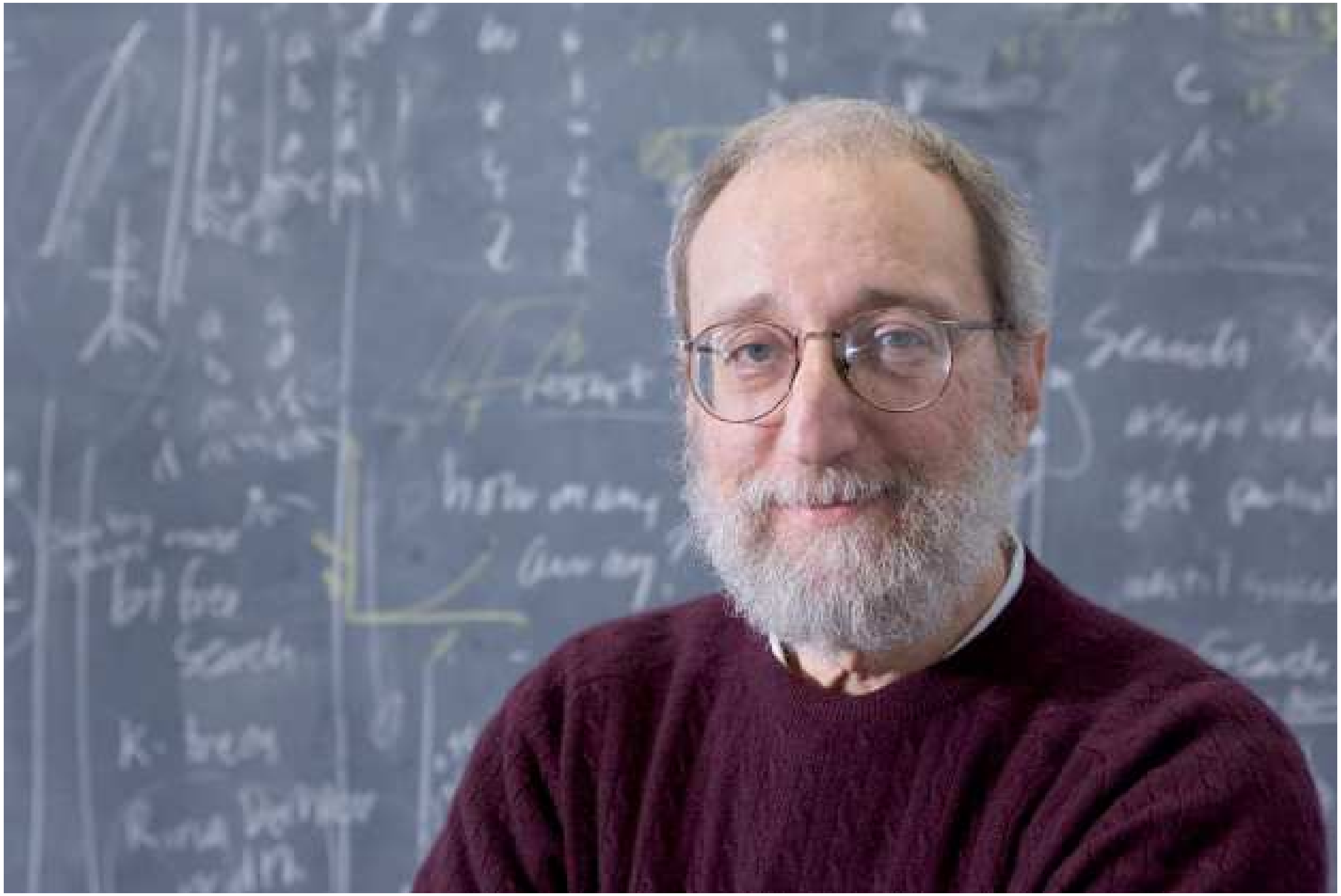
n-queens : Given an $n \times n$ chessboard, arrange n queens so that none is attacking another.

configuration : Given d_i options for each of the n components of a computer system (CPU, backplane, storage system, NICs), find a set of options compatible with the choices the customer has already made.

scheduling : Given a set of temporal constraints (eg, $t_2 \geq t_1 + 30$), find a feasible set of times.

What algorithm would you use?

Gene Freuder: Father of Constraint Programming



Gene Freuder (UNH 1977?–2001)

Chronological Backtracking

Do not expand any partial solution that violates a constraint.

Break

- asst 3, asst 4
- projects

Forward Checking

When assigning a variable, remove the conflicting values for all connected variables. Backtrack on domain wipeout.

Arc consistency: for every value in the domain of x, there exists a value in the domain of y that satisfies all the constraints.

Heuristics for CSPs

Variable choice: choose most constrained variable (smallest domain)

- want to keep tree small, failing quickly

Value choice: try least constraining value first (fewest removals)

- might as well succeed sooner if possible

Example Results

	BT	FC	FC+MCV
USA	> 1M	2K	60
n-Queens	> 40M	> 40M	820K
Zebra	3.9M	35K	500
Random 1	420K	26K	2K
Random 2	940K	77K	15K

Maintaining Arc Consistency

Ensure every value for x has a legal value in all neighbors y. If one doesn't, remove it and ensure consistency of all y.

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while Q is not empty
    $(x, y) \leftarrow$ pop Q
    if **revised**(x, y) then
        if x's domain is now empty, return failure
        for every other neighbor z of x
            push (z, x) on Q

revised(x, y)
revised$\leftarrow$ false
foreach v in x's domain
    if no value in domain of y is compatible with v
        remove v from x's domain
        revised$\leftarrow$ true
return *revised*

Other Algorithms for CSPs

- (Conflict-directed) Backjumping
- Dynamic backtracking
- Randomized restarting

Course projects!

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!