Constraint Satisfaction
Part II
CSE 473

473 Topics

Blind
Informed (Heuristics)
Constraint Satisfaction (Factored)
Adversarial

Search
Knowledge Representation
Problem Spaces
Agency

What We Covered Last Week

• Constraint Satisfaction as search
• Backtracking methods:
  • Chronological
  • Backjumping
  • Conflict-directed backjumping

Plan For Today

• Improving Efficiency, continued
  • Forward Checking (FC)
  • Constraint Propagation
  • Application of CSP
  • Automatically Rendering UIs

Forward checking

Keep track of remaining legal values for unassigned variables
Terminates search when any variable has no legal values

WA NT Q SA NSW V T
**Forward checking**

- Keeps track of remaining legal values for unassigned variables.
- TERMINATE search when any variable has no legal values.

**Constraint propagation**

- Forward checking propagates information from assigned to unassigned variables, leading to partial/full assignment for all values.

**Arc consistency**

- Simplest form of propagation makes each arc consistent:
  
  \[ X \rightarrow Y \text{ is consistent iff for every value } x \text{ of } X \text{ there is some allowed } Y \text{.} \]

- If \( X \rightarrow Y \) is not consistent, all \( X \) values must be rechecked.
Dynamic variable ordering

- In the N-queens examples we assumed
  - First x1 then x2 then ...
  - But this order not required
  - Any order ok with respect to completeness
  - A good order leads to huge speedup
  - A good heuristic (MRV):
    - Choose variable w/ minimum remaining values
    - This is easy if one is doing FC

DVO MRV => WOW!!

Automatically Rendered Interfaces for Classroom Controller

Automatically rendered Interfaces for Classroom Controller

Modeling User Interfaces

- simple types: $\text{int} | \text{float} | \text{string} | \text{bool}$
- derivative types: $\langle \tau, C_\tau \rangle$
- vectors: $\tau_i \langle \tau \rangle$
- containers: $\{\tau_i \in \{1...n\}\}$
- actions: $\tau \rightarrow \text{nil}$
Modeling User Interfaces

- **simple types:** `int`, `float`, `string`, `bool`
- **derivative types:**
- **vectors:**
- **containers:**
- **actions:**

Examples of Available Widgets

- **Pointer and Keyboard**
- **Touch Screen**

Modeling User Interfaces: Optional Attributes

- Label
- Set of likely values
- Exact value required
- ...

Examples of Available Widgets
Cost Function For Primitive Widgets

\[ \mathcal{F}(\langle \text{int}, [0,10]\rangle, \text{exact }= \text{false}) = 3 \]

\[ \mathcal{F}(\langle \text{int}, [0,10]\rangle, \text{exact }= \text{false}) = 1 \]

UI Rendering As Search

- States
- Operators
- Start state
- Goal test

UI Rendering As CSP

- Variables
- UI Elements
- Domains
- Sets of available widgets
- Constraints
- Total size of the interface
Branch And Bound?

- **Gist:** prune branches if they are no better than what you already have

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Constraint Satisfaction Recap

- CSP = Factoring a state space
- Chronological Backtracking (BT)
- Backjumping (BJ)
- Conflict-Directed Backjumping (CBJ)
- Forward checking (FC)
- Constraint Propagation
- Dynamic variable ordering heuristics
- Preprocessing Strategies