



10-607
Computational
Foundations for
Machine Learning

Data Structures

Instructor: Pat Virtue

Plan

Dynamic Programming

- Overlapping subproblems
- Examples

Data Structures

- Dense vs sparse structures
- Trees
- BFS and DFS
- Stacks and Queues
- Other tree implementations
- Graphs (next time)

Dynamic Programming


Previous lecture slides

Abstractions vs. Data Structures

Abstractions

- List
- Set
- Map (Dictionary)
- Tree
- Queue (FIFO)
- Stack (LIFO)
- Priority Queue
- Graph

Data Structures

- Array (fixed size)
 - Array (variable size)
 - Linked List
 - Doubly-Linked List
 - Multidimensional Array
 - Tensor
 - Hash Map
 - Binary Search Tree
 - Balanced Tree
 - Trie
 - Stack
 - Heap
 - Graph
 - Bipartite Graph
 - Sparse Vector
 - Sparse Matrix
- 

Data Structures for ML

Examples...

Data:

- Dense feature vector (array)
- Sparse feature vector (sparse vector)
- Design matrix (multidimensional array)

Models:

- Decision Trees (tree)
- Bayesian Network (directed acyclic graph)
- Factor Graph (bipartite graph)

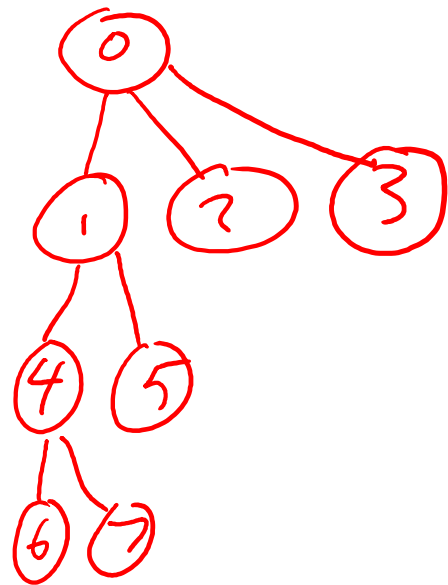
Algorithms:

- Greedy Search (weighted graph)
- A* Search (priority queue/heap)
- Forward-backward for HMM (trellis)

Tree to Predict C-Section Risk

Learned from medical records of 1000 women (Sims et al., 2000)

Negative examples are C-sections



- 0 [833+,167-] .83+ .17-
- 1 Fetal_Presentation = 1: [822+,116-] .88+ .12-
- 4 | Previous_Csection = 0: [767+,81-] .90+ .10-
- 6 | | Primiparous = 0: [399+,13-] .97+ .03-
- 7 | | Primiparous = 1: [368+,68-] .84+ .16-
- | | | Fetal_Distress = 0: [334+,47-] .88+ .12-
- | | | | Birth_Weight < 3349: [201+,10.6-] .95+ .05-
- | | | | Birth_Weight >= 3349: [133+,36.4-] .78+ .22-
- | | | Fetal_Distress = 1: [34+,21-] .62+ .38-
- 5 | Previous_Csection = 1: [55+,35-] .61+ .39-
- 2 Fetal_Presentation = 2: [3+,29-] .11+ .89-
- 3 Fetal_Presentation = 3: [8+,22-] .27+ .73-

Plan

Dynamic Programming

- Overlapping subproblems
- Examples

Data Structures

- **Dense vs sparse structures**
- Trees
- BFS and DFS
- Stacks and Queues
- Other tree implementations
- Graphs (next time)

Dense vs sparse structures

Vector dot product example

- Linear regression model $y = \mathbf{w}^T \mathbf{x} + b$
- Where \mathbf{x} represents the contents of text data, e.g., e-mail or book review

x_1 : 1: free, 0: o.w

x_2 : # ALL CAPS words

x_3 : # money appears

$$w_1 x_1 + w_2 x_2 + w_3 x_3 + b$$

Vocabulary with $|V|$ num of words

0 0

x_1 : 1 if first word in V in text, 0 o.w.

bad

10 1

x_2 : 1 if second

$[(2, 10), (1200, 3)]$

0 0

3 1

x_{1200} : 1 if cat in text, 0.o.

$[2, 1200]$
 w_2 w_{1200}

Dense vs sparse structures

Matrix multiplication with special structure

- Example: diagonal matrices

Plan

Dynamic Programming

- Overlapping subproblems
- Examples

Data Structures

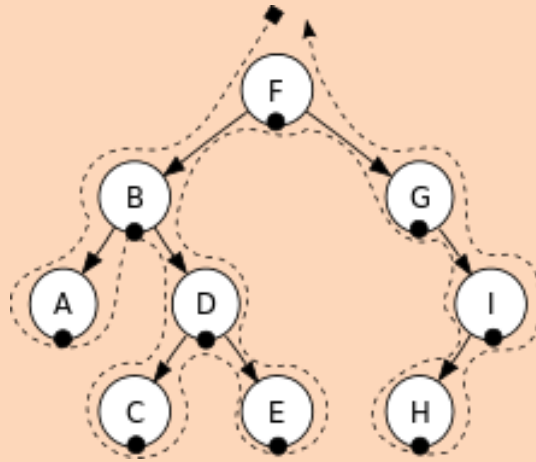
- Dense vs sparse structures
- **Trees**
- BFS and DFS
- Stacks and Queues
- Other tree implementations
- Graphs (next time)

Trees

Notebook

Tree Traversals

Depth First Search



Breadth First Search

